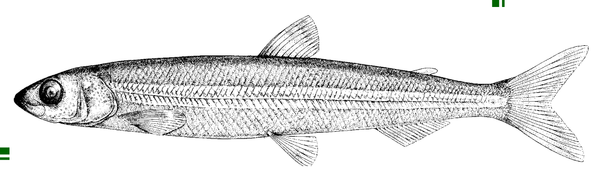
Half Moon Bay
Baseline Fish Survey
Grays Harbor, Washington



Prepared for:

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1. INTRODUCTION

The Grays Harbor Federal Navigation Channel (Navigation Channel) begins in the Pacific Ocean and continues through Grays Harbor to the Chehalis River near the city of Cosmopolis in Grays Harbor County, Washington (Figure 1). The navigation channel is approximately 24 miles long and covers roughly 1,300 acres. The U.S. Army Corps of Engineers (Corps) dredges annually to maintain the Navigation Channel's dimensions. Channel maintenance involves dredging selected areas that have developed shoals as well as maintaining turning basins. The upstream reaches of the navigation channel are within the river's thalweg near the mouth of the Chehalis River near Aberdeen, Washington.

In an attempt to minimize dredging activities, the Corps constructed the South and Point Chehalis jetties in the early 1990s to concentrate tidal currents and carry material from the entrance of Grays Harbor to offshore areas (USACE 1998). Half Moon Bay is a coastal feature that formed at the landward end of the South Jetty in Grays Harbor. It formed in 1945, six years after the South Jetty was constructed (USACE 1998). The Point Chehalis Revetment was constructed between 1950 and 1956 to combat rapid retreat of the Half Moon Bay shoreline. The unprotected portion of the shoreline has retreated at an average rate of 5-10 ft per year since 1956. Annually, approximately 54,000 cubic yards of sand is eroded from the upper beach area and deposited immediately offshore at the northern entrance of Half Moon Bay (USACE 1998). Nearshore nourishment of Half Moon Bay was first utilized in 1992 in conjunction with Navigation Channel dredging. Both bottom dump barge and hopper dredge materials are deposited offshore. Wave action carries the material shoreward, forming a gentle-sloping shallow bay. Offshore wave shoaling creates one of the most popular surfing locations in Washington, as well as numerous other recreational opportunities, while providing protection for the toe of the Point Chehalis Revetment (USACE 1998).

A winter storm occurring on 10 December 1993 caused a breach to occur in the South Jetty, adjacent to South Beach. The breach increased in size reaching nearly 500 ft wide during a six-week period. The breach raised concerns over loss of South Shore Beach; impacts to the City of Westport’s sewer outfall, wastewater treatment plan, and municipal well; facilities at Westhaven State Park; and the Navigation Channel (USACE 1998). The breach was filled in March 1994 by the Corps with approximately 600,000 cubic yards of material dredged from the Navigation Channel (Figure 2). At this time, a study was initiated to evaluate ongoing erosion problems near the South Jetty and identify alternative long-term solutions. In June 1997, the Corps issued the results of the study and nine alternative actions (USACE 1998). The study concluded another breach may adversely affect the Navigation Channel and increase the likelihood of erosion and concurrent flooding of public property located adjacent to Half Moon Bay, including the City of Westport sewage treatment facility and the U.S. Coast Guard Surf Tower. Recommendations included an extension of the South Jetty combined with periodic beach nourishment of Half Moon Bay (USACE 1998). In 1999, the plan was modified to include the construction of a wave diffraction mound, a gravel/cobble transition beach, and repair of landward jetty structures (USACE 2004). A storm occurring in November/December 2001 threatened the haul road used to transport material to the repair site and caused the Corps to place additional materials along the west shoreline of Half Moon Bay (January 2002) in an attempt to extend the life of the breach fill (USACE 2004). Alternatives discussed included no action, placement of additional transition gravel/cobble material, and sand placement. The placement of approximately 25,000 cubic yards of sand on the breach fill was proposed as the best alternative.

In 2004, the Corps began to develop a long-term strategy for the maintenance of the Grays Harbor south jetty and entrance reach of the Navigation Channel. Methods for maintaining the breach fill placed in 1994 and re-nourished in 2002 will likely be investigated. One or more alternatives for maintaining the breach fill may involve addressing the extensive erosion occurring along the southwest shoreline of Half Moon Bay, including interim sand placement in November/December 2004. Periodic sand placement will help to maintain the breach fill until a long-term management strategy can be formulated and implemented.

In order to evaluate and compare the environmental impacts of various proposals, the Corps initiated a baseline survey of fish utilization of Half Moon Bay. The Corps contracted with R2 Resource Consultants in June 2004 to conduct weekly surveys of the nearshore fish assemblage in Half Moon Bay. This study was initiated to, in part, assist with defining the existing environmental conditions in Half Moon Bay, specifically identifying the nearshore fish assemblage residing in Half Moon Bay throughout a period when the greatest species diversity are thought to be present. This report provides a detailed summary of weekly beach seine surveys, conducted at two locations in Half Moon Bay, initiated in late June and continued through August 2004.

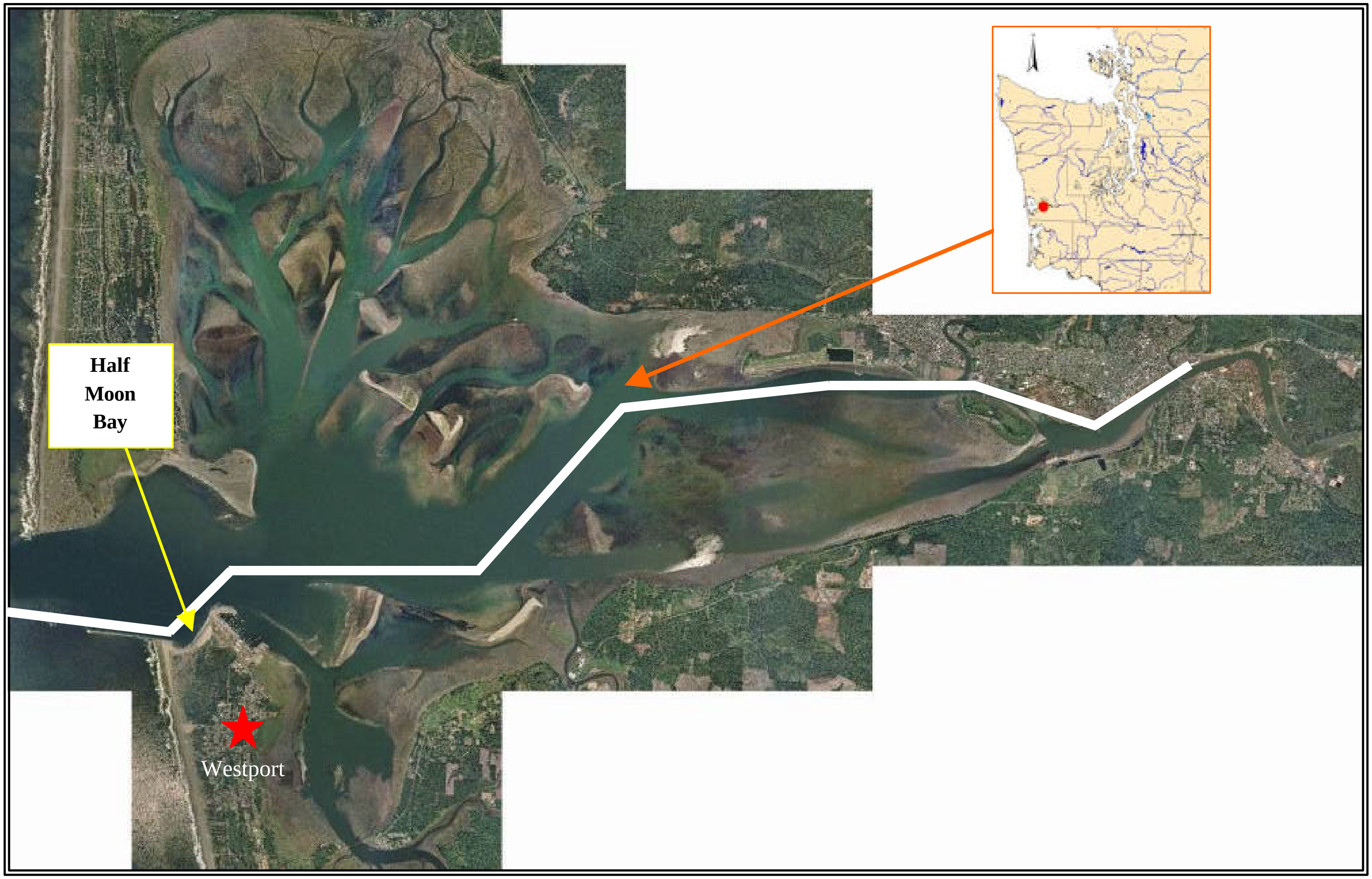

Figure 1. Grays Harbor Federal Navigation Channel, Westport, Washington.

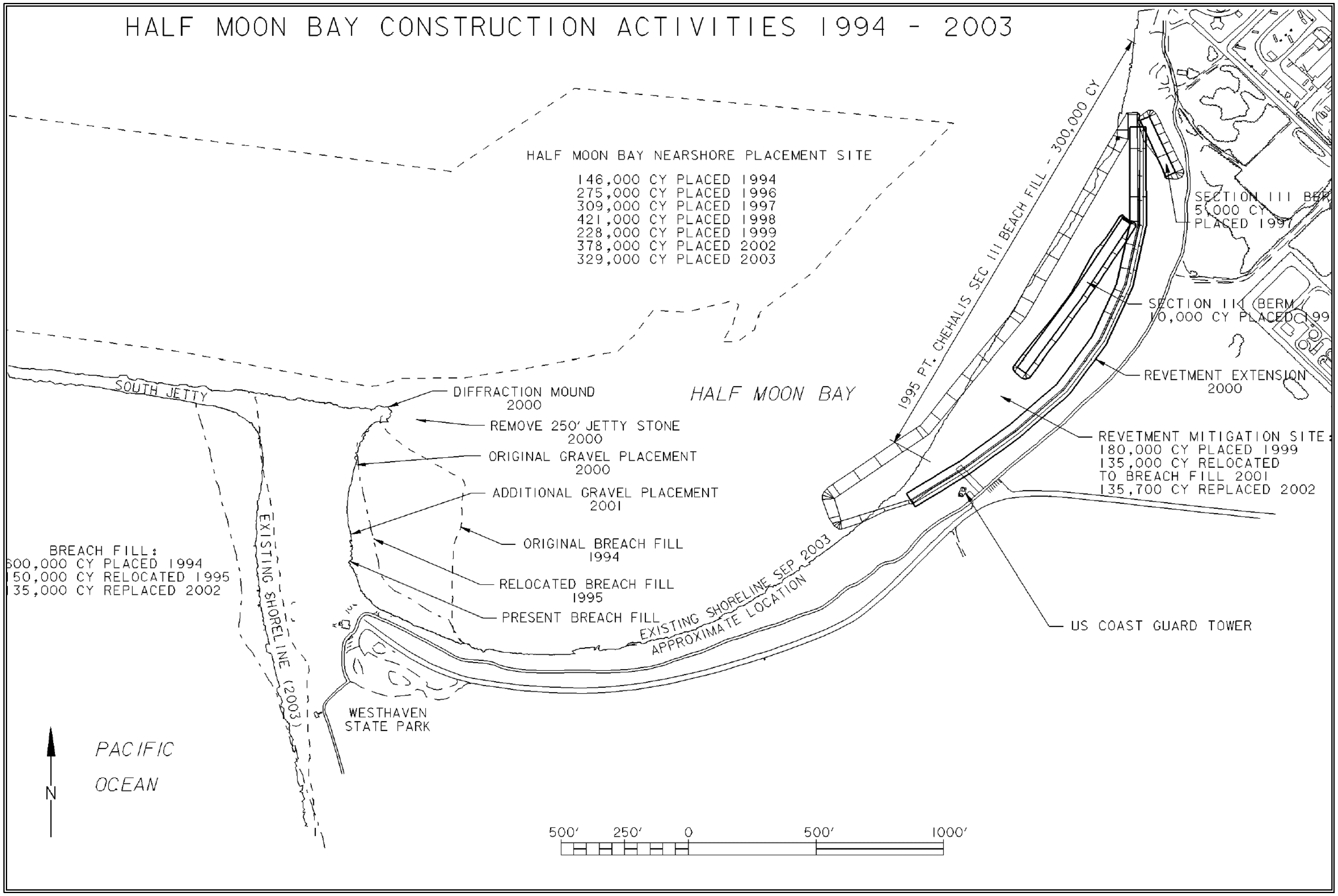

Figure 2. Construction activities occurring in Half Moon Bay, Westport, Washington, 1994-2003 (adapted from USACE 2004).

2. ENVIRONMENTAL SETTING

2.1 STUDY AREA

Half Moon Bay is located on the Washington Coast in Grays Harbor, near the city of Westport. Grays Harbor is approximately 45 miles north of the mouth of the Columbia River and 110 miles south of the entrance to the Strait of Juan de Fuca (see inset Figure 1). Grays Harbor receives a discharge from a 2,550 mi^2 watershed containing the Chehalis, Humptulips, Hoquiam, Wishkah, Johns, and Elk rivers, making it the fourth largest estuarine environment in the western United States (Seiler 1989; USACE 1998). The Chehalis River drains approximately 2,200 mi^2 and contributes greater than of 80 percent of the freshwater flow into Grays Harbor estuary making it the largest watershed in Washington outside of the Columbia River Basin (Seiler 1989; USACE 1998).

Grays Harbor is composed of both estuarine and open-water (ocean) habitats (Levinton 1982). Extreme semi-diurnal tides fluctuate over eleven feet in the spring causing expansive mudflats to be exposed in Grays Harbor and an extensive labyrinth of channels forming at ebb tide (Figure 1). The surface area of Grays Harbor ranges from approximately 38 mi^2 at mean low water to 94 mi^2 at mean high water (USACE 1998). The lower Chehalis River and inner harbor are heavily populated and industrialized (Seiler 1989). The outer harbor (i.e., North and South bays) is sparsely populated, considerably wider, and primarily comprised of shallow estuarine habitats enclosed by two spits, Point Brown to the north and Point Chehalis to the south (Seiler 1989; USACE 1998). In 1999, the Corps conducted a baseline study that was initiated to improve the understanding of juvenile salmonid residency in Half Moon Bay. Since 1999, the south jetty has been modified through construction of a wave diffraction mound and removal of stone along a submerged jetty remnant. These modifications have changed the depth and wave climate (environmental conditions) of Half Moon Bay.

2.2 AQUATIC RESOURCES

Both anadromous and euryhaline fish species inhabit Grays Harbor (Jeanes et al. 2003). Deschamps et al. (1971) and Jeanes et al. (2003) documented more than 40 fish species during beach seining activities conducted in Grays Harbor (Table 1), including six species of salmonids. Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*) and coho (*O. kisutch*) salmon,

Table 1. Common and scientific names of species documented in Grays Harbor, Washington (source = Deschamps et al. 1971; Brix et al. 1974; Brix 1981; Simenstad and Eggers 1981; Simenstad et al. 2001; Jeanes et al. 2003).

Common Name	Scientific Name	Common Name	Scientific Name
Steelhead	*Oncorhynchus mykiss*	Shiner perch	*Cymatogaster aggregata*
Coastal cutthroat trout	*O. clarki clarki*	Redtail surfperch	*Amphistichus rhodoterus*
Chinook salmon	*O. tshawytscha*	Striped seaperch	*Embiotoca lateralis*
Coho salmon	*O. nerka*	Pile perch	*Rhacochilus vacca*
Chum salmon	*O. keta*	Silver surfperch	*Hyperprosopon ellipticum*
Bull trout	*Salvelinus confluentus*	Bay pipefish	*Syngnathus leptorhynchus*
White sturgeon	*Acipenser transmontanus*	Black rockfish	*Sebastes melanops*
Dungeness crab	*Cancer magister*	Pacific staghorn sculpin	*Leptocottus armatus*
Red rock crab	*Cancer productus*	Buffalo sculpin	*Enophrys bison*
Saddleback gunnel	*Pholis ornata*	Prickly sculpin	*Cottus asper*
Snake prickleback	*Lumpenus sagitta*	Cabezon	*Scorpaenichthys marmoratus*
Rock greenling	*Hexagrammos decagrammus*	Surf smelt	*Hypomesus pretiosus*
Kelp greenling	*H. lagocephalus*	Longfin smelt	*Spirinchus thaleichthys*
Lingcod	*Ophiodon elongatus*	Eulachon	*Thaleichthys pacificus*
Pacific herring	*Clupea pallasii*	Speckled sanddab	*Citharichthys stigmaeus*
Northern anchovy	*Engraulis mordax*	Sand sole	*Psettichthys melanostictus*
American shad	*Alosa sapidissima*	Rock sole	*Lepidopsetta bilineata*
Pacific sand lance	*Ammodytes hexapterus*	English sole	*Parophrys vetulus*
Pacific sandfish	*Trichodon trichodon*	Starry flounder	*Platichthys stellatus*
Pacific tomcod	*Microgadus proximus*	Arrow goby	*Clevelandia ios*
White seaperch	*Phanerodon furcatus*	Threespine stickleback	*Gasterosteus aculeatus*

steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*) and native char (*Salvelinus spp.*) frequent the waters of Grays Harbor. Grays Harbor also provides habitat for several forage fish species including Northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), American shad (*Alosa sapidissima*), and smelt species (*Osmeridae spp*.) (Emmett et al. 1991; Hart 1973). In addition to fish species, Dungeness (*Cancer magister*) and red rock crab (*Cancer productus*), Mysids (*Mysis spp.*), and shrimp (*Crangon spp.*) are present periodically throughout Grays Harbor and Half Moon Bay (Deschamps et al. 1971; Jeanes et al. 2003).

2.2.1 Salmonids

Chinook Salmon

Mixed (native and non-native origin) spring and fall Chinook occur in the Grays Harbor system (WDFW et al. 1994). Timing of entry into estuaries varies considerably for juvenile Chinook salmon (Healey 1982; 1991). Most juvenile Chinook that migrate to salt water as subyearlings (fry), termed ocean-type, are primarily progeny of fall Chinook stocks (Healey 1991). A smaller percentage of juvenile Chinook that enter salt water as yearlings (termed stream-type) are the progeny of spring Chinook stocks. Peak yearling migration occurs in late April through early June, while fry migration to salt water occurs earlier, typically from April through late May (Simenstad et al. 1982; Healey 1991). Congleton et al. (1982) reported that Chinook fry (42-60 mm FL) were abundant in the Skagit River estuary from late April through May. Brix (1981) found peak catches of Chinook fry in Grays Harbor during mid-June, but continued to capture subyearling Chinook near the mouth of the Hoquiam River from early March through September. Estuarine residency periods of juvenile Chinook can range from as short as six weeks (northern Puget Sound) to 29 weeks (Grays Harbor) (Simenstad et al. 1982). Owing to their many life history patterns, juvenile Chinook occupy the widest variety of estuarine habitats (Healey 1982; Simenstad et al. 1982; Healey 1991). Chinook fry frequent the same estuarine habitat as chum fry, while yearling Chinook are generally found in neritic habitats, bypassing shallow water estuarine habitats (Healey 1991). After rearing in the estuary, Chinook salmon will typically spend three to four years in the ocean before returning to spawn. Peak river entry timing for Chehalis River spring Chinook is not known, but is believed to be in January and February (WDFW et al. 1994). Fall Chinook will begin to enter Grays Harbor in early September, with peak entry in October (WDFW et al. 1994).

Chum Salmon

Juvenile chum salmon seaward migration is directly related to latitude, and typically peaks in Washington during late March through early May (Simenstad et al. 1982; Salo 1991). Congleton et al. (1982) found that juvenile chum abundance in the Skagit River estuary increased from March through early May, peaking in late April and early May. After the first week in May, chum abundance declined until only “a few hundred” remained by the end of June, and no chum fry were captured in early July. Juvenile chum in the Skagit River estuary ranged from 40-48 mm FL. Deschamps et al. (1971) captured juvenile chum salmon (38-40 mm mean FL) in upper Grays Harbor (near mouth of Hoquiam River) from early February through mid-June. Juvenile chum salmon estuarine residence periods have been reported as short as five weeks (Quillayute

River estuary), to as long as 23 weeks (Hood Canal) (Simenstad et al. 1982). Chum fry often reside in schools in shallow sublittoral areas (e.g., salt marshes and shallow bays containing eelgrass) until they reach 50-60 mm fork length, when they become more common in deeper neritic habitats (Healey 1982; Simenstad et al. 1982; Salo 1991). Adult chum typically return from the ocean to Grays Harbor in early October, with peak entry in early November (WDFW et al. 1994).

Coho Salmon

Coho salmon migrate to salt water during April and June, after spending one year of residency in fresh water habitats (Sandercock 1991). Durkin (1982) captured coho smolts (110-160 mm FL) in the upper Columbia River estuary for six weeks between late April and early June, peaking from 6-17 May. Migration of larger smolts usually occurs earlier and more rapidly than smaller coho smolts. Catches of juvenile coho salmon (71-106 mm FL) peaked in mid- and late May and again in early July on the lower Snohomish River (Pentec 1992). Brix (1981) reported catching yearling coho in upper Grays Harbor from April through June, peaking in early May. Like yearling Chinook salmon, coho generally spend less time in shallow water areas, and enter neritic habitats almost immediately upon entry to the estuary, preferring exposed cobble or gravel beaches (Healey 1982; Simenstad et al. 1982; Sandercock 1991). Adult coho return to Grays Harbor from mid- to late-September through mid-December (WDFW et al. 1994).

Steelhead/Rainbow Trout

Steelhead, the anadromous form of rainbow trout, spend the first one to several years of their life in freshwater before migrating to saltwater. Steelhead typically return to freshwater to spawn within 2 to 4 years (Busby et al. 1996). Unlike the other Pacific salmon species, steelhead do not die after spawning and are capable of spawning in successive years (iteroparous). Steelhead are divided into two groups based on sexual maturity when entering freshwater. Summer (termed stream maturing) steelhead enter freshwater in an immature state during late spring and summer months, while winter steelhead (termed ocean maturing) enter freshwater with well-developed sexual organs in late fall and winter months (Busby et al. 1996). Peak spawning usually occurs in February and March (Busby et al. 1996). Two wild summer and eight wild winter steelhead stocks have been identified in the Grays Harbor watershed (WDFW et al. 1994).

Coastal Cutthroat Trout

Coastal cutthroat trout exhibit early life history characteristics similar to coho and steelhead whereby juveniles spend an extended time rearing in freshwater before outmigrating as smolts (Leider 1997). Like steelhead, cutthroat trout are also iteroparous, spawning several times during their lifetime. Within a given drainage basin, resident (non-migratory), fluvial (freshwater migrants), and anadromous (marine migrants) life history patterns are often present. Age at first anadromy can vary, but due to their proximity to rough costal waters, cutthroat trout in the Chehalis River probably emigrate to the estuary between ages 3 and 5 (8-10 inches TL) (Johnston 1982). Most coastal cutthroat return to freshwater the same year they migrate to the ocean, but may or may not spawn that year. Based on surveys conducted by Weyerhaeuser Corporation and the Quinault Indian Nation in the West Branch Hoquiam River, it is believed that coastal cutthroat trout are abundant and widespread in Chehalis River/Grays Harbor (WDFW 2000). Coastal cutthroat return to their natal streams to spawn from late fall through late winter months with peak spawning occurring in February (Johnson et al. 1999).

Native Char

Bull trout and Dolly Varden (*S. malma*) are two native char species present in western Washington. Bull trout and Dolly Varden are difficult to distinguish based on physical characteristics, and both have similar life history traits and habitat requirements (WDFW 1998). Like coastal cutthroat trout, Bull trout can exhibit numerous life history strategies including an anadromous form, and three diadromous forms; adfluvial, fluvial, and resident (Pratt 1992). Historically, in Washington bull trout were primarily thought of as an inland, freshwater species (WDFW 1998). Recent studies indicate that anadromous populations are present in coastal and Puget Sound drainages (F. Goetz, US Army Corps of Engineers, *pers. comm.*). Anadromous bull trout are now thought to only exist where their coastal ranges overlap with Dolly Varden (Haas and McPhail 1991; Haas and McPhail 2001).

An exhaustive search of fish survey literature from the lower Chehalis River/Grays Harbor documented 15 native char captures dating back to a large native char that was captured in a beach seine in 1966 near Cow Point in April (Deschamps et al. 1970). Tokar et al. (1970) caught three native char in May 1968 near Cow Point. Brix (1974) collected one native char near Moon Island on 4 March 1973, and one native char on 19 March 1973 near Oakville on the Chehalis River (approximate RM 47). Brix et al. (1974) captured three native char near Moon Island in 1974, one on 20 May and two more in July (1 July and 14 July). Brix (1981) collected three native char near Moon Island in 1977 (18 March, 2 May, and 15 June). Simenstad and Eggers (1981) reported catching two native char at Cow Point in March 1981, measuring 550 mm and 440 mm. Prior to studies conducted by the Corps in the lower Chehalis River/Grays Harbor beginning in 2003, the most recent char capture occurred in April 2000 by Simenstad et al. (2001) while monitoring a slough restoration site near Cosmopolis. Unfortunately, raw data records for that specific char could not be located (C. Simenstad, University of Washington, *pers. comm.*; A. Wick, Anchor Environmental, *pers. comm.*). Recently, the Corps has documented an additional 15 native char captures in lower Chehalis River beginning at sites located near Cosmopolis, and continuing downstream to sites near Hoquiam, Washington. Acoustic telemetry data indicate that native char reside in this reach of the Chehalis River from mid-February through mid-July when they appear to begin their migration to natal streams, presumably located outside of the Grays Harbor watershed, as spawning has not been documented within the watershed. Native char did not utilize the nearshore habitat along Half Moon Bay from 2003-2004, despite their presence in the lower Chehalis River.

Studies in Northern Puget Sound systems provide information on the migration patterns of anadromous native char. In the Skagit and Snohomish rivers, native char sub-adults migrate downstream between April and May at two or three years of age (Goetz et al. 2004). By early autumn sub-adult native char are approximately 250-300 mm long when they move back to the lower portions of their natal streams where they are thought to overwinter. Native char migrate back to the marine environment as early as February where they spend several months in preparation for the spawning migration. Mature native char (age=4, >400 mm in length) leave the tidal waters in May through July and begin their upstream spawning migration (Goetz et al. 2004).

2.2.2 Forage Fish

Northern Anchovy

Anchovies are streamlined, silvery forage fish that gather in immense schools to feed, breed and migrate. There are approximately 125 known anchovy species, but only one, the Northern anchovy, resides in waters of the Pacific Northwest (Hart 1973). The Northern anchovy is abundant along the Pacific coast from Baja California to British Columbia. The Northern anchovy may spend significant time in estuaries and bays such as Grays Harbor particularly, during spring and summer months. They are believed to move offshore during the fall and winter (WDFW 2004). The Northern anchovy may remain deeper in the water column (60-100 fm) during daylight hours, rising to the surface at night (Kucas 1986). Anchovies feed by filter feeding or biting prey primarily during the day.

Northern anchovy are pelagic spawners (spawning in open water) and therefore do not require specific shoreline areas for successful spawning (WDFW 1998). Any spawning locations in Washington are not well identified, but anchovy eggs have been report in Puget Sound and off the mouth of the Columbia River (WDFW 1998). Anchovy distribution seems to be linked to water temperature changes and spawning is temperature dependant (Kucas 1986; WDFW 2004). Spawning requires temperatures between 10 and 23°C (WDFW 2004). Anchovies are generally short-lived, surviving on average 4 years, and growing to about 150 mm (Kucas 1986). However, a single female may spawn several times each year.

Commercial harvest of anchovies began when the Pacific sardine fishery collapsed in the 1940s. There has been a commercial anchovy harvest for bait in Grays Harbor in recent years. Overall annual anchovy harvest in Washington averaged 29 tons from 1990 – 1996 (WDFW 1998). Increasing populations of Pacific sardine and a renewed interest in sardine fishery will likely decrease interest in Northern anchovy (DFO 2002). No anchovy stock condition or habitat assessment activities are currently being undertaken in Washington coastal waters.

Pacific Herring

The taxonomic family Clupeidae is represented by three species in the Pacific Northwest: the American shad, Pacific sardine and the Pacific herring. Adult herring may reach a length of 13 inches (33 cm) in British Columbia (Hart 1973). Pacific herring mature in 3 to 4 years, but may live up to 19 years; however, few fish live beyond 9 years of age (Emmett et al. 1991). Adult herring spawn at specific nearshore sites throughout Washington. These sites define the herring stocks, geographically distinct spawning populations. Three of these stocks spawn on the Washington coast; Willapa Bay, Grays Harbor and the Columbia River Estuary (Stout et al. 2001). Spawning usually take place at night in shallow subtidal zones (Stout et al. 2001). Herring eggs are attached to submerged vegetation including eelgrass or algae in late January through April. Juvenile herring generally remain inshore for the few years of their lives. Adult herring will return to natal spawning sites to spawn (Emmett et al. 1991).

Pacific herring feed selectively on pelagic plankton, but filter feeding has also been observed (Emmett et al. 1991). Juvenile and adult herring are important forage fish for squid, salmonids, sculpin, lingcod, sand sole and several other species. They are also eaten by many species of birds and mammals. Herring eggs are also forage items for many aquatic species, and are harvested for human consumption (roe) (Emmett et al. 1991).

Herring is a valuable forage fish of considerable interest due to its popularity as recreational fishing bait, commercial fishery, and general indicator of ecosystem health (WDFW 2004). The Pacific herring was included in the 1974 “Boldt Decision” and local herring stocks and fisheries are cooperatively monitored and managed by Washington Department of Fish and Wildlife and local area Tribal governments (WDFW 2004). Unlike Puget Sound stocks, there is only occasional monitoring or assessment of coastal herring populations and no directed commercial fisheries on herring populations on the Washington coast (WDFW 2004).

American Shad

The American shad, the world's largest herring species, was introduced to the Pacific Northwest from the North Atlantic coast in the early 1870s (Lamb and Edgell 1986). Originally introduced into the Sacramento River, American shad have spread quickly in rivers and at sea reaching British Columbia by 1891 (Hart 1973). Current Pacific Ocean distribution is from southern California north to Cook Inlet, Alaska and the Kamchatka Peninsula (Facey and Van Den Avyle 1986). American shad are a euryhaline anadromous species that return from the ocean to its freshwater natal area to spawn. Average sized shad measure 12 to 25 inches (30-64 cm) in length. Shad will spawn in rivers, estuaries, and streams during the spring and summer months (Emmett et al. 1991). Entry for spawning in the Columbia River begins in May (LCFRB 2004). Spawning runs are temperature dependant, taking place from 60 to 65°F (15.6 to 18.3°C) in the Columbia River (Wydoski and Whitney 2003). American shad are broadcast spawners usually over clean gravels and sand. Juveniles rear in fresh or estuarine water for up to one year before moving offshore. Adult shad typically spend 3 to 4 years at sea before returning to spawn. Shad may spawn more than once, but many will die after spawning (Petersen et al. 2003).

Commercial fisheries for shad have existed on the Columbia River, but due to poor market demand and incidental catches of protected salmon, significant commercial fisheries no longer exist in the Pacific Northwest. There is, however, a building recreational fishery with a portion utilized as baitfish (PSMFC 2004). Whereas the Columbia River dams have negatively impacted other fish species, American shad populations have been on the rise since their inception. Shad successfully pass above the dams, have good spawning and rearing habitat in the reservoirs and low exploitation rates (Petersen et al. 2003).

Pacific Sand Lance

The Pacific sand lance is a unique fish not closely related to any other taxonomic group. It is sometimes mistakenly referred to as "candlefish," a term more appropriately used for another forage fish, the eulachon. The Pacific sand lance is found from southern California around the North Pacific Ocean to the Sea of Japan and across Arctic Canada (Hart 1973). It is common in nearshore waters of Washington State (WDFW 1998). The Pacific sand lance exhibits a variety of behavior strategies, including offshore schooling, utilizing tidal channels, and burying themselves in nearshore or deepwater sands. Sand lance may feed diurnally in the open water column, and seek refuge in sand substrates at night (Auster and Stewart 1986). Because this species burrows in the substrate it requires a habitat with suitable current velocities to keep the substrate sufficiently oxygenated. This habitat is often found at the mouths of estuaries (Emmett et al. 1991).

Pacific sand lance spawn in the intertidal zone of sandy or rocky beaches (WDFW 2004). Spawning timing for Puget Sound is from November to February (WDFW 1998). Spawning generally takes place during high tide. The eggs become coated with sand particles and are dispersed with the tide. Sand lance eggs will incubate for approximately one month (Robards et al. 1999). The planktonic larvae and young of the year will rear in bays and nearshore waters (Robards et al. 1999). The sand lance is of particular importance as a prey item for juvenile salmon whereby on average, 35% of juvenile salmon (60% of juvenile Chinook) diets are comprised of sand lance sand lance (WDFW 2004). Sand lance have not been regularly harvested for bait or human consumption in Washington State (WDFW 2004). However, there is a sizeable commercial fishery for sand lance (referred to as sandeels) in the North Atlantic Ocean. No comprehensive study of sand lance populations on Washington's outer coast have been undertaken, but sand lance spawning has been documented in Grays Harbor (WDFW 2004).

Smelt Species

The family Osmeridae (smelt) consists of approximately twelve known living species, including surf smelt (*Hypomesus pretiosus*), longfin smelt (*Spirinchus thaleichthys*), and eulachon (*Thaleichthys pacificus*). Surf smelt is a pelagic forage fish distributed from Monterey Bay, California north to Prince William Sound, Alaska and are common throughout the marine waters of Washington State. Surf smelt may reach a total length of 12 inches (30 cm), however 8 inches (19 cm) is more common for northern waters, such as Grays Harbor (Hart 1973). Maximum lifespan is thought to be 5 years (WDFW 2004). When spawning, surf smelt deposit adhesive eggs on specific substrates containing coarse sand. Surf smelt spawning beaches are widespread throughout Washington. In particular, surf smelt spawn in the Grays Harbor region at Point Brown (near Ocean Shores), the area beginning at the South Jetty south to Twin Harbors State Park (near Westport), and in South Bay (WDFW 1994b). Peak spawning months for coastal areas are mid-May through October (WDFW 1994b). Smelt spawn just prior to high tide, with each smelt spawning over a period of several days (Hart 1973). During the summer (warmer) months smelt eggs hatch in 11 to 16 days (WDFW 2004). Juvenile surf smelt rear in nearshore areas, becoming sexually mature during their second year. Surf smelt do not die after spawning and may spawn in successive seasons.

Both commercial and recreational surf smelt fisheries are widespread in Washington. Harvest occurs of spawning and non-spawning fish (WDFW 2004). In Washington, surf smelt are harvested by recreation anglers on ocean beaches by dipping or raking in shallow water while they spawn or jigging off piers and docks in Puget Sound. Commercially, smelt are harvested using similar methods, or more often by using drag or purse seines (WDFW 2004).

3. METHODS

In an attempt to provide continuity with past surveys efforts, R2 Resource Consultants utilized beach seine surveys at two sites that were sampled in 1999 (Jeanes and Hilgert 1999). Site 1 (46.9028484 N; 124.12858 W), the western-most site, is located approximately 300 ft south of the eastern-most edge of the South Jetty and receives more protection from the surf due to its proximity to the south jetty (Figure 3). Site 2 (46.9038365 N; 124.12344 W), is located approximately 1,200 ft east of Site 1, between the U.S. Coast Guard lookout tower and eastern-most edge of the South Jetty and was established to survey areas not protected by the South Jetty, thus exposed to greater influence from surf (Figure 3).

A 121 ft-long, 6.5-ft (37- X 2-m) deep beach seine constructed of two 59-ft (18-m) wings, each composed of 0.25-inch (6-mm) mesh, was used during each survey trip. The central collection bag measured 6.5-ft (2-m) deep by 3-ft (1-m) wide and was constructed of 0.2-inch (5-mm) treated knotless nylon mesh. Each wing was attached to 2-in. (51 mm) diameter, 4.0-ft (1.2-m) long wooden poles with a stainless steel ring at the center of the leads. The beach seine was deployed by boat using 100-ft (30-m) long lead ropes attached to the stainless steel rings. One end of the seine was pulled in a semi-circular fashion while the other end was secured to the shore using a fluke-style anchor. The seine was manually retrieved parallel to shore using the lead ropes for the first 66 ft (20-m) with wings approximately 130 ft (40-m) apart, and from a distance of approximately 33 ft (10-m) apart for the final 33 ft (10-m) to shore. As utilized in this configuration, the beach seine samples approximately an area of 5,597 ft^2 (520 m^2) and volume of 27,915 ft^3 (790 m^3) (Simenstad et al. 1991). Beach seine survey trips were conducted weekly beginning on 21 June and continuing to 24 August 2004 for a total of ten survey dates. On each survey date two samples were collected within one hour of the low and two from within one hour of high slack tide at each of two survey sites for a total of 80 beach seine hauls over the ten week study period (2 sites X 2 seine pulls per site X 2 tides X 10 trips = 80 seine hauls).

All fish were collected immediately from the bag and transferred to a holding tank (live car) where they were identified and enumerated; non-salmonid species were released were enumerated and measured to the nearest mm total length. Salmonids were anesthetized with 70 $mg \cdot l^{-1}$ buffered tricaine methanesulfonate (MS-222), measured to the nearest mm fork length, and released within 100 ft of their capture location. On three separate occasions, individual seine hauls were subdivided due to the extreme quantity of organisms collected to decrease mortalities and adhere to WDFW collection permit conditions. Random sub samples of the seine haul, consisting of enumeration of a minimum of 1,000 individuals, were extrapolated volumetrically to estimate total number of organisms in the beach seine haul. Overwhelming quantities of smelt and flatfish also prevented enumeration to species on several occasions, in which case voucher specimens were collected to verify species. A random sub sample of salmonids and non-salmonids were collected and preserved for stomach content analysis on 29 June 2004 (subsequent analyses to be conducted by the Corps and not contained within this document). Stomach content fish were preserved whole in a 40% buffered formalin solution (Simenstad et al. 1991). Stomach content species (number in parenthesis) collected included: shiner perch (n=8); starry flounder (n=6); Chinook salmon (n=20); American shad (n=4); Pacific herring (n=1); Pacific sand lance (n=4); English sole (n=10); speckled sanddab (n=2); sand sole (n=2) and surf smelt (n=20).

Water quality measurements were collected at mid-water column in Half Moon Bay during each survey. Measurements were taken using a Hydrolab Quanta® portable multi-parameter water quality monitoring sonde. Salinity, water temperature, dissolved oxygen and pH were collected during both high and low tide surveys at a location immediately offshore (46.9049854 N; 124.12671 W), from the survey sites (Figure 3). The water quality monitoring system was calibrated per manufacturers instructions each week before the survey was conducted. Representative photographs were obtained during beach seine surveys of the survey sites, tide levels, and fish species collected (see Appendix A) and recorded on a photo log on the original field data form. All fish and water quality data were entered electronically using MS Excel™ and cross-referenced with original field data forms for quality assurance purposes. All data analyses were conducted in MS Excel™, unless otherwise noted.

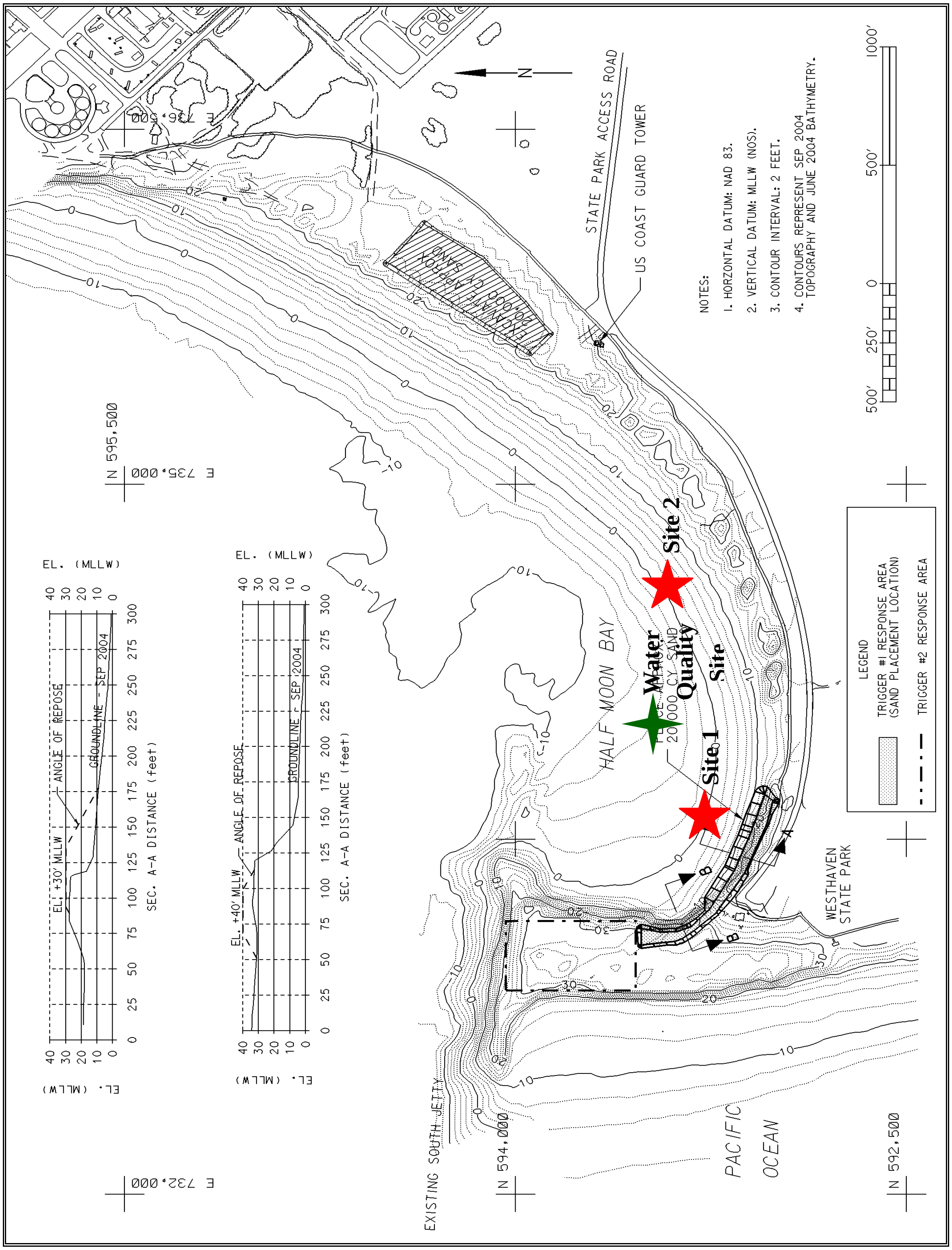

Figure 3. Beach seine survey and water quality monitoring sites established in Half Moon Bay, Westport, Washington, 2004 (base map source = USACE 2004).

4. RESULTS

4.1 TOTAL CATCH

A total of 91,132 fish and crabs, consisting of 32 different species were captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington (Tables 2 and 3; See Appendix B for complete beach seine data). The forage fish assemblage dominated the total catch, comprising more than 86% (n=78,476), from beach seine surveys conducted in Half Moon Bay (Table 3). Of the forage fish, Northern anchovy and American shad constituted more than 46% and 35% of the total catch, respectively. Both species, however, were heavily influenced by seine hauls conducted on 15 and 22 July, when greater than 98% of both species were captured on these dates (Figure 4). While lower in number (n=13,298), the smelt species (primarily surf smelt) were more consistently represented in beach seine survey catches and comprised 17% of the total forage fish catch (Table 3). Surf perches (family *Embiotocidae*; primarily represented by shiner perch) were the second most abundant fish assemblage accounting for more than 8.5% (n=7,951) of the total catch of fish and crabs (Table 3; Figure 4). Chinook salmon (n=1,752) comprised the majority of the salmonid catch, which comprised 2% of the total catch of fish and crabs. Except for Dungeness crab (1.5% of total catch), the remaining species accounted for less than 1% of the total catch of fish and crab captured at Half Moon Bay monitoring sites (Table 3; Figure 4).

Overall, a median catch per unit effort (CPUE) of 0.29 individuals$\cdot$ m^{-3} (std. dev. = 3.57$\cdot$ m^{-3}) were captured on each seine haul conducted in Half Moon Bay in 2004 (Figure 5). As stated earlier, the total numbers are skewed by seine hauls occurring on 15 and 22 July, thus the median is more appropriate than the mean statistic (1.44$\cdot$ m^{-3}). Despite these individual seine hauls, the catch trend increased early in the study period, peaked in mid/late July, and decreased thereafter (Figure 5). While larger, the median CPUE at Site 2 (1.72 individuals$\cdot$ m^{-3}; std. dev. = 4.61 individuals$\cdot$ m^{-3}) was not significantly greater than that from Site 1 (1.16 individuals$\cdot$ m^{-3}; std. dev. = 2.33 individuals$\cdot$ m^{-3}) (Mann-Whitney rank sum test, T=121.0, P=0.241). Forage fish dominated the catch at both sites, however a greater variety of species were present at Site 1 compared to Site 2 (Table 3; Figure 6). Flatfish (sand, rock, and English sole, and starry flounder) and crabs (Dungeness and red rock crabs) were virtually non-existent at Site 2 (Figure 6). Tide level did not appear to influence catch at either site as median CPUE during low tides were higher (1.90 individuals$\cdot$ m^{-3}; std. dev. = 4.71 individuals$\cdot$ m^{-3}) but not significantly different (Mann-Whitney rank sum test, T=118.0, P=0.345) than high tides (0.98 individuals$\cdot$ m^{-3}; std. dev. = 2.35 individuals$\cdot$ m^{-3}).

Table 2. Common and scientific names of species captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

Common Name	Scientific Name
Coastal cutthroat trout	*Onchorhynchus clarki clarki*
Chinook salmon	*O. tshawytscha*
Rainbow/Steelhead trout	*O. mykiss*
Dungeness crab	*Cancer magister*
Red rock crab	*C. productus*
Saddleback gunnel	*Pholis ornata*
Snake prickleback	*Lumpenus sagitta*
Kelp greenling	*Hexagrammos decagrammus*
Rock greenling	*H. lagocephalus*
Lingcod	*Ophiodon elongatus*
Cabezon	*Scorpaenichthys marmoratus*
Black rockfish	*Sebastes melanops*
Pacific Sandfish	*Trichodon trichodon*
Shiner perch	*Cymatogaster aggregata*
Silver surfperch	*Hyperprosopon ellipticum*
Red tail surf perch	*Amphistichus rhodoterus*
Striped seaperch	*Embiotoca lateralis*
Bay pipefish.	*Syngnathus leptorhynchus*
Pacific herring	*Clupea pallasii*
Pacific sand lance	*Ammodytes hexapterus*
Northern anchovy	*Engraulis mordax*
American shad	*Alosa sapidissima*
Buffalo sculpin	*Enophrys bison*
Pacific staghorn sculpin	*Leptocottus armatus*
Surf smelt	*Hypomesus pretiosus*
Longfin smelt	*Spirinchus Thaleichthys*
Eulachon	*Thaleichthys pacificus*
English sole	*Parophrys vetulus*
Sand sole	*Psettichthys melanostictus*
Pacific sanddab	*Citharichthys sordidus*
Starry flounder	*Platichthys stellatus*
Threespine stickleback	*Gasterosteus aculeatus*
Pacific tomcod	*Microgadus proximus*

Table 3. Number of fish and crabs captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

	21-Jun-04		29-Jun-04		8-Jul-04		15-Jul-04		22-Jul-04		29-Jul-04		4-Aug-04		11-Aug-04		17-Aug-04		24-Aug-04		Grand
Species	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Total
N. anchovy			4		16	480	1	24,201	11,735		5	1	5		1			5			**36,454**
A. shad			4		1	64		17,083	10,846				8								**28,006**
Smelt spp.	463	52	1,154	374	176	1,000	1,712	4,815	604	506	43	20	94	202	1,165	340	133	410	29	6	**13,298**
P. sand lance			17				12	69		5								65	316		**484**
P. herring	1		4	1	1				225					1				1			**234**
Perch spp.	77	422	640	808	525	305	869	364	562	815	567	214	401	454	144	304	142	82	173	83	**7,951**
Chin. salmon	49	73	470	83	102	23	107	419	128	154	49	31	1	14	15	11	4	14		5	**1,752**
C. trout					1																**1**
R. trout			1																		**1**
Rockfish spp.	24		12	3					70				34		18		426	1	11		**599**
Sculpin spp.	56	12	50	1	131	4	15	4	36	8	30	6	30	6	13	10	41	25	36	3	**517**
Sole spp.	101	13	13		34		1		40	8	2	1	10	5	1	1	7	12	1		**250**
Starry flounder	6	1	4	2	2						1		4	2				1			**23**
Gunnel/Prickle	2		2		9	1	1		95		1		2				1		1		**115**
Greenling spp.	10	1	1						2				19		1		13		3		**50**
T. stickleback	2	2	6	1		1				7	1	2	2	3		3	3	9	1		**43**
Bay Pipefish							1									1			1	1	**4**
Cabezon																	4				**4**
Lingcod																	1		1		**2**
P. sandfish											1										**1**
P. tomcod			1																		**1**
D. crab	211	10	208	3	518		20	1	133	11	82	5	22	4			89	4			**1,321**
Red rock crab	1	2	1		2				9								6				**21**
TOTAL	**1,003**	**588**	**2,592**	**1,276**	**1,518**	**1,878**	**2,739**	**46,956**	**24,485**	**1,514**	**782**	**280**	**632**	**691**	**1,358**	**670**	**870**	**629**	**573**	**98**	**91,132**

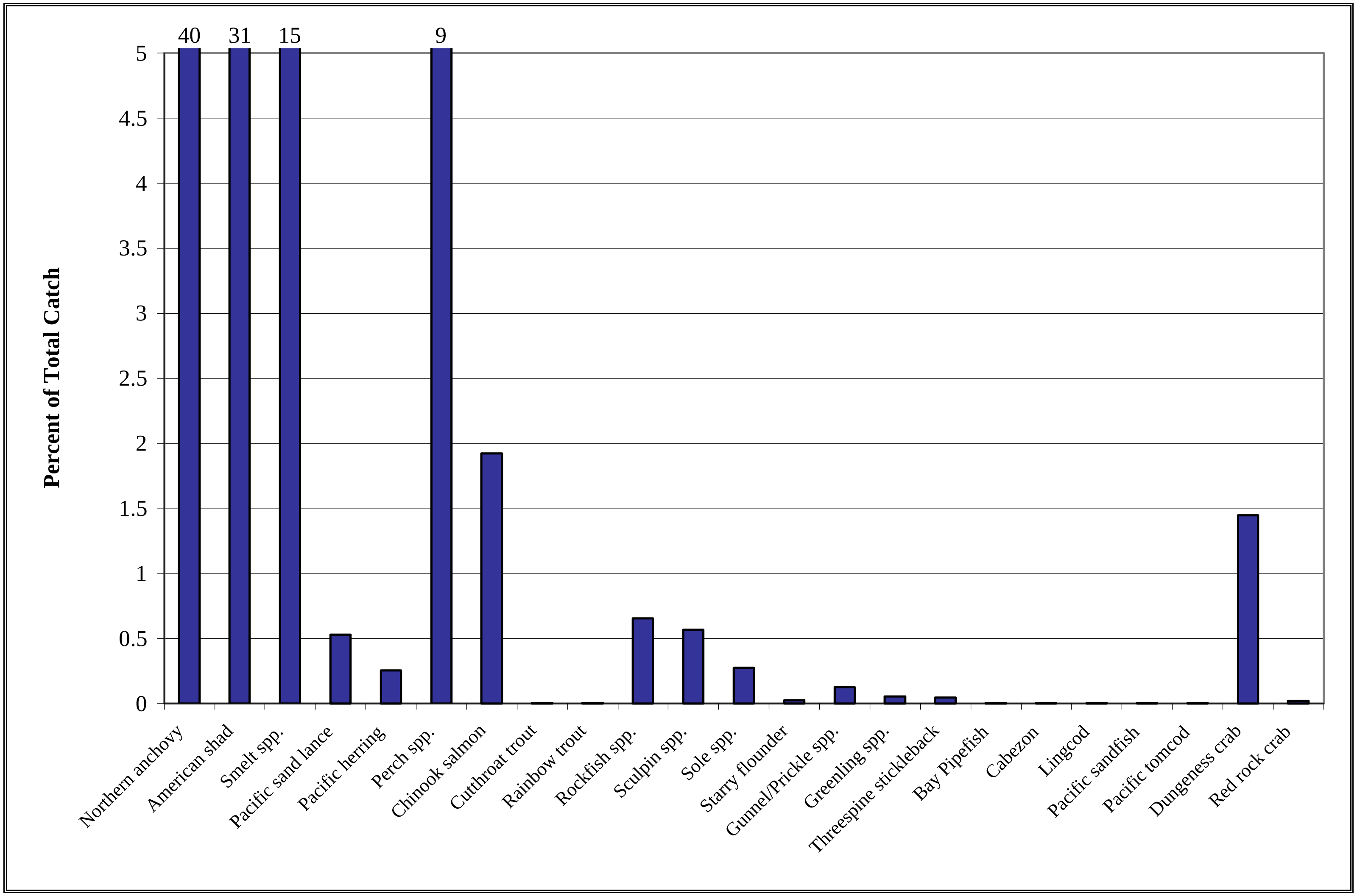

Figure 4. Percent composition of total catch from 23 fish and crab species/species assemblages captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

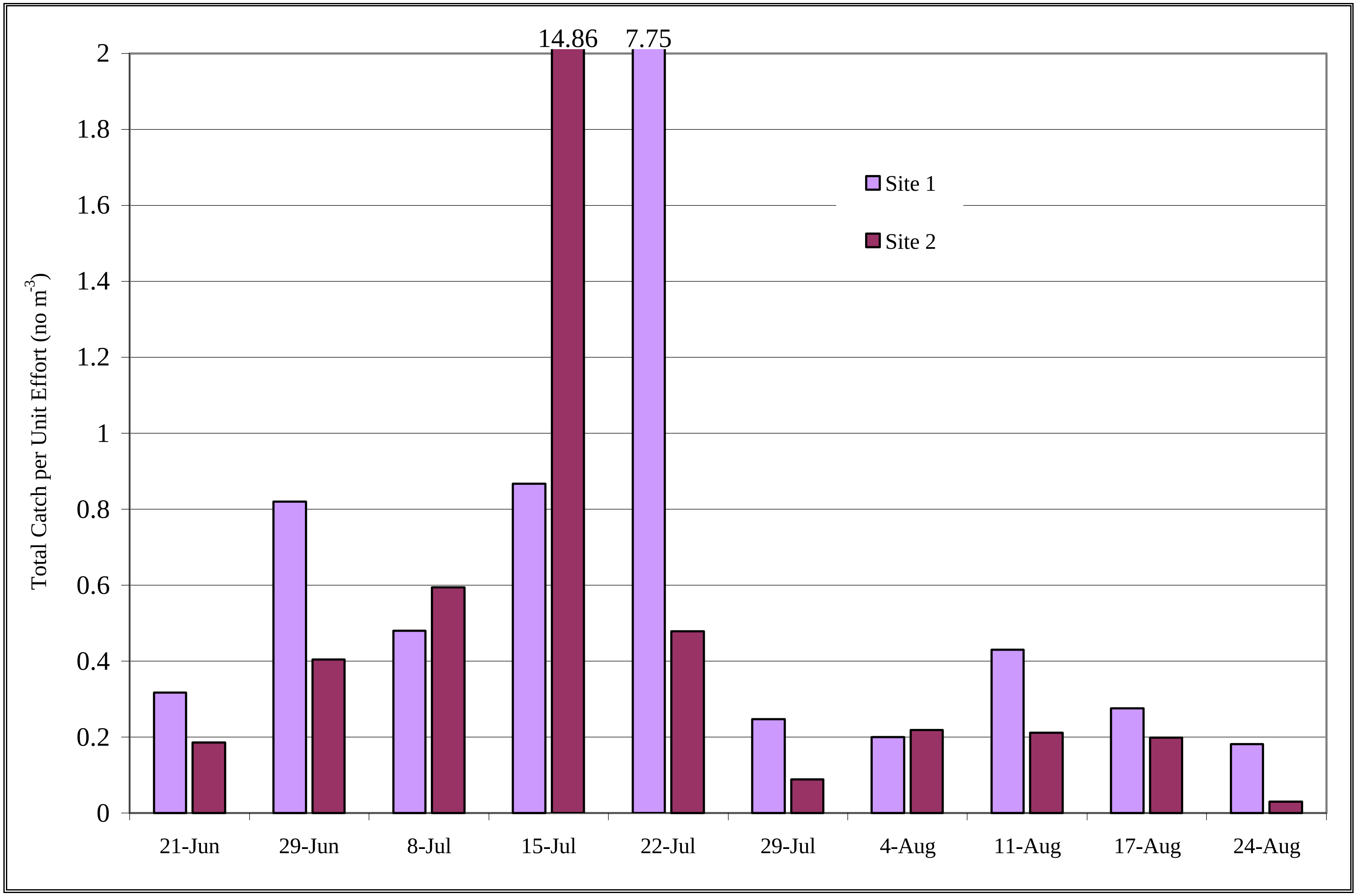

Figure 5. Catch per unit effort (no.· m^{-3}) indices of fish and crab captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

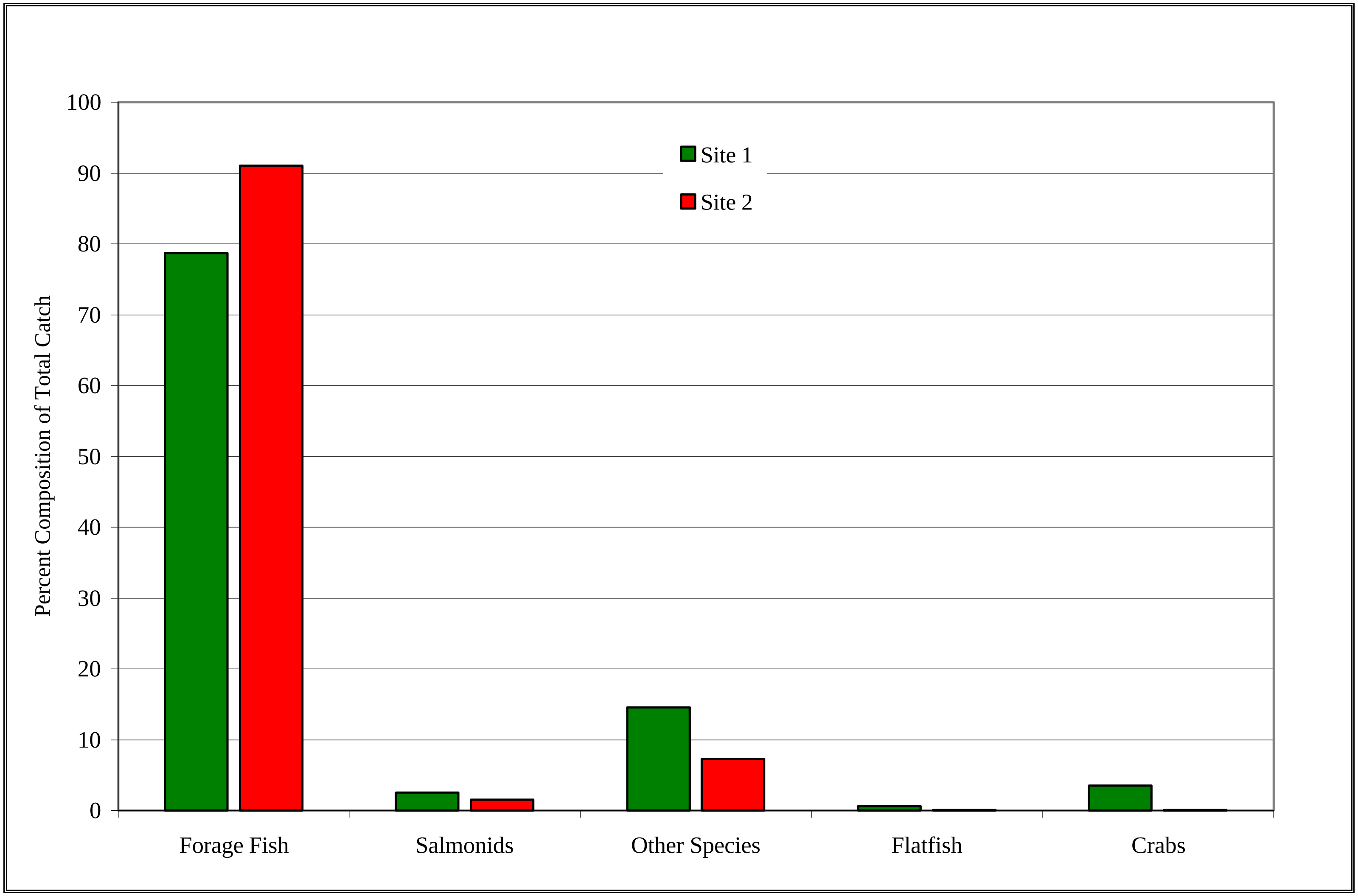

Figure 6. Percent composition of fish and crab species assemblages captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

4.2 SALMONIDS

Chinook salmon (n=1,752) comprised the vast majority (>99.8%) of the salmonid catch (Table 3; Figure 4). The lone cutthroat trout (FL = 300 mm) and steelhead (FL= 550 mm) were captured at Site 1 on 8 July and 29 June, respectively. Only one Chinook was an overyearling fish, measuring 300 mm FL (captured 17 August), the remaining Chinook were young of the year (yoy) measuring less than 155 mm FL. Overall, an average catch per unit effort (CPUE) of 0.02 Chinook· m^{-3} (std. dev. = 0.03· m^{-3}) were captured on each seine haul conducted in Half Moon Bay in 2004 (Figure 7). The Chinook catch generally increased early in the study period, peaking during late July, and decreased thereafter (Figure 7).

Overall, 52.8% (n=925) of the Chinook were captured at Site 1 and 47.2% (n=827) at Site 2 (Table 3). While larger than Site 2, the median CPUE at Site 1 (0.016 individuals· m^{-3}; std. dev. = 0.045 individuals· m^{-3}) was not significantly greater than from Site 2 (0.008 individuals· m^{-3}; std. dev. = 0.044 individuals· m^{-3}) (Mann-Whitney rank sum test, T=105.0, P=0.969). Tide level did not appear to influence catch at either site as median CPUE during low tides were higher (0.014 individuals· m^{-3}; std. dev. = 0.053 individuals· m^{-3}) but not significantly different (Mann-Whitney rank sum test, T=1120, P=0.623) than high tides (0.009 individuals· m^{-3}; std. dev. = 0.027 individuals· m^{-3}). Average juvenile Chinook fork length increased throughout June (80.0 mm), July (86.6 mm), and August (94.5 mm). Mean size of juvenile Chinook salmon was slightly greater at Site 2 (85.6 mm FL) compared to Site 1 (85.0 mm FL), but the difference was not significant (t-test, T=-0.393, P=0.352) (Table 4). The majority of juvenile salmon ranged from 85-90 mm FL (Figure 8).

Table 4. Minimum, mean, maximum, and standard deviation fork lengths (mm) of juvenile Chinook salmon captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

	Site 1				**Site 2**			
Date	Min	Mean	Max	Std. Dev.	Min	Mean	Max	Std. Dev.
21-Jun	59.0	80.5	99.0	9.0	51.0	76.8	107.0	9.8
29-Jun	65.0	84.1	153.0	11.5	66.0	73.7	84.0	9.3
8-Jul	68.0	87.8	115.0	10.0	85.0	92.6	102.0	5.2
15-Jul	68.0	83.8	108.0	8.3	74.0	84.1	104.0	7.4
22-Jul	75.0	86.9	102.0	7.1	63.0	87.3	122.0	11.8
29-Jul	76.0	86.6	110.0	8.0	65.0	87.0	120.0	11.2
4-Aug	92.0	92.0	92.0	-	84.0	95.9	128.0	12.3
11-Aug	72.0	88.1	101.0	7.2	82.0	96.6	118.0	10.8
17-Aug	95.0	97.0	101.0	3.5	86.0	99.1	115.0	7.5
24-Aug					81.0	91.8	99.0	8.0
Grand Total	*59.0*	*85.0*	*153.0*	*9.5*	*51.0*	*85.6*	*128.0*	*12.2*

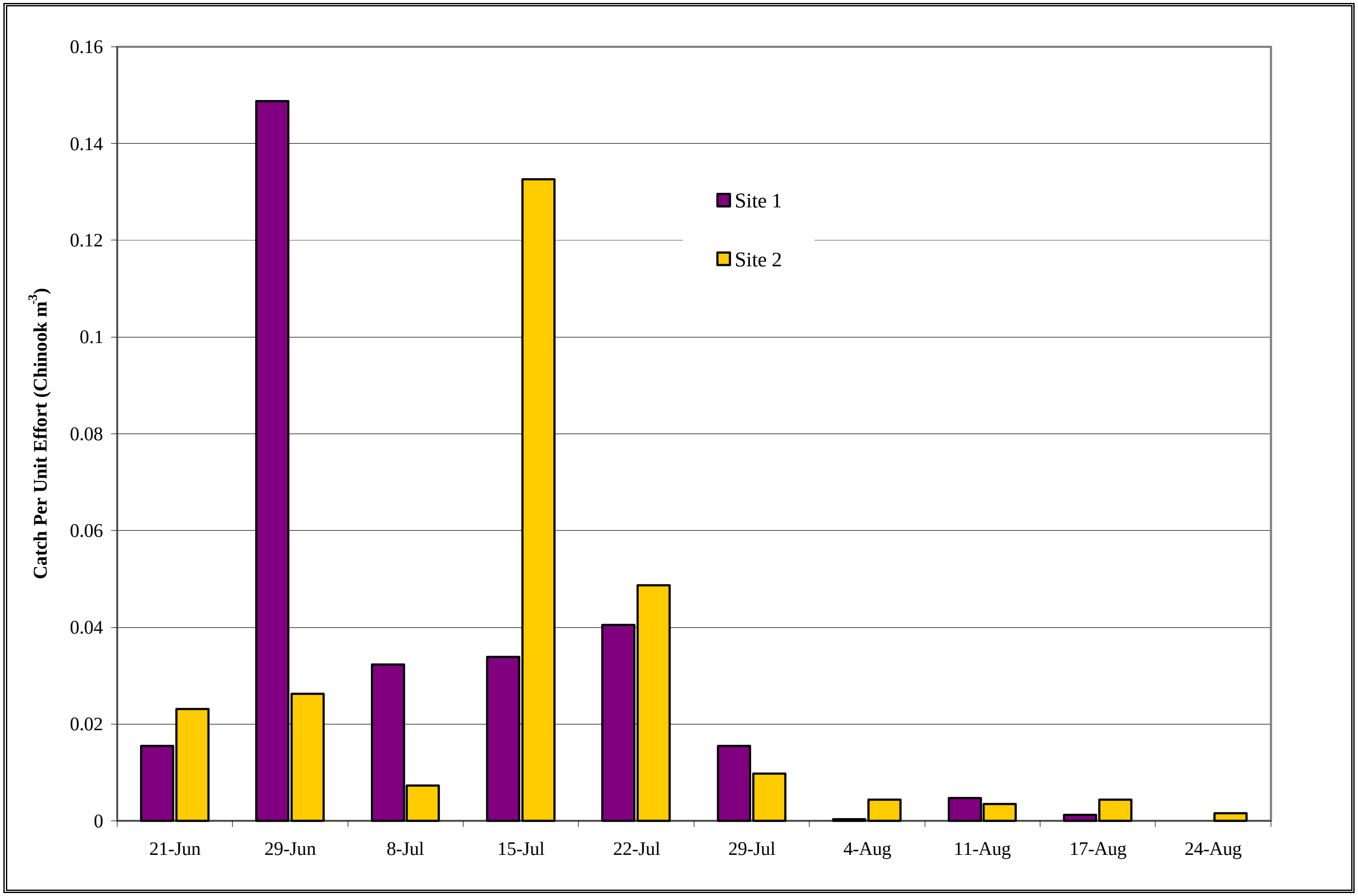

Figure 7. Catch per unit effort (no· m^{-3}) indices of Chinook salmon captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

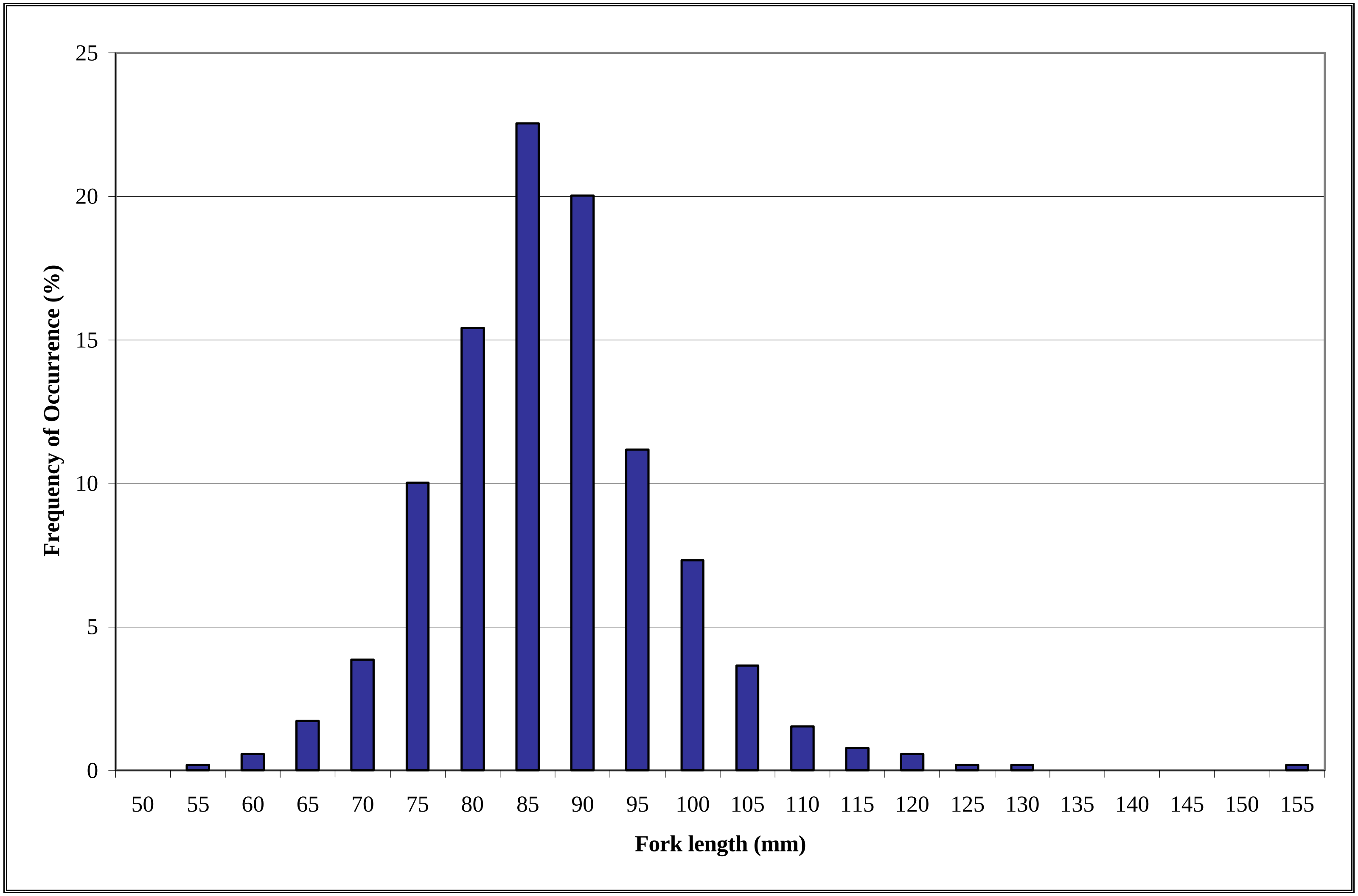

Figure 8. Length frequency of juvenile Chinook salmon captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

4.3 FORAGE FISH

Northern anchovies comprised the majority (n=36,454; 47%) of the forage fish species assemblage followed by American shad (n=28,006; 36%), smelt (n=13,298; 17%), Pacific sand lance (n=484; <1%), and Pacific herring (n=234; <1%). Overall, an average catch per unit effort (CPUE) of 0.24 forage fish· m^{-3} (std. dev. = 0.25· m^{-3}) were captured on each seine haul conducted in Half Moon Bay in 2004. Surf smelt were the lone species captured during all sample events at both survey sites (Table 3; Figure 9). The remaining species capture frequencies were sporadic throughout the study period (Table 3; Figure 9).

The median CPUE at Site 1 (0.128 individuals· m^{-3}; std. dev. = 2.29 individuals· m^{-3}) was not significantly different than Site 2 (0.113 individuals· m^{-3}; std. dev. = 4.58 individuals· m^{-3}) (Mann-Whitney rank sum test, T=111.0, P=0.678) (Figure 10). Like site location, tide level did not influence catch, as median CPUE during low tides was greater (495 individuals· m^{-3}; std. dev. = 14,823 individuals· m^{-3}) than CPUE at high tides (45.0 individuals· m^{-3}; std. dev. = 7,294 individuals· m^{-3}) however this difference was not significant (Mann-Whitney rank sum test, T=126.5, P=0.112). Mean length of forage fish species over the study period was greatest for Pacific herring (105.1 mm; std. dev.=26.2 mm), followed by American shad (103.4 mm; std. dev.=12.1 mm), Northern anchovy (94.6 mm; std. dev.=9.3 mm), smelt (88.1; std. dev.=20.5 mm), and Pacific sand lance (80.6 mm; std. dev.=14.7 mm). Mean forage fish length remained consistent throughout the study period (Figure 11). Mean size of smelt (the only species present at all tides/dates/sites) was slightly greater at Site 2 (95.3 mm TL) compared to Site 1 (86.1 mm TL), but the difference was not significant (t-test, T=-1.74, P=0.099) (Table 5).

Table 5. Mean length (mm TL) and standard deviation (in parenthesis) of forage fish captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

Date	N. Anchovy	P. Herring	P. Sand lance	A. Shad	Smelt
21-Jun		98.0			87.9(31.8)
29-Jun		139.0(36.8)	110.8(7.9)	91.0(8.5)	80.7(20.3)
8-Jul	90.1(7.5)	74.0		94.5(7.0)	98.8(25.2)
15-Jul	96.3(11.2)		92.2(13.6)	97.7(10.8)	86.9(19.2)
22-Jul	96.4(5.6)	93.3(7.6)		107.5(10.1)	80.7(6.5)
29-Jul	91.2(11.5)				87.9(20.4)
4-Aug	90.7(17.0)	120.0		122.0(1.0)	84.4(15.4)
11-Aug					90.8(12.8)
17-Aug	97.0(3.3)	96.0	72.6(7.9)		89.1(9.4)
24-Aug			72.8(3.6)		106.4(26.6)
Total	94.6(9.3)	105.1(26.2)	80.6(14.7)	103.4(12.1)	88.1(20.5)
Min./Max. Length	75/131	74/165	60/120	74/130	39/172

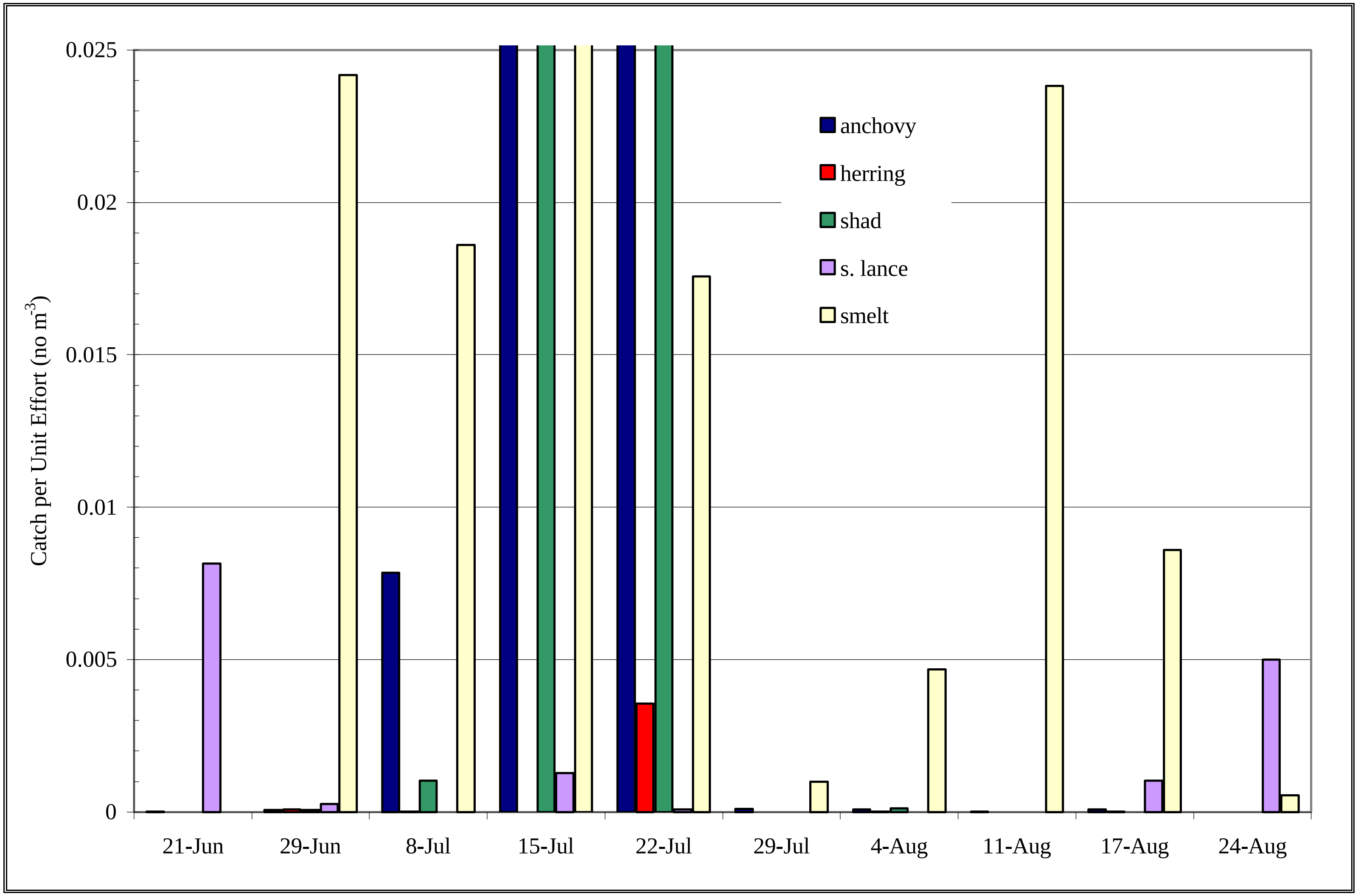

Figure 9. Catch per unit effort (no.· m^{-3}) indices of forage fish captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

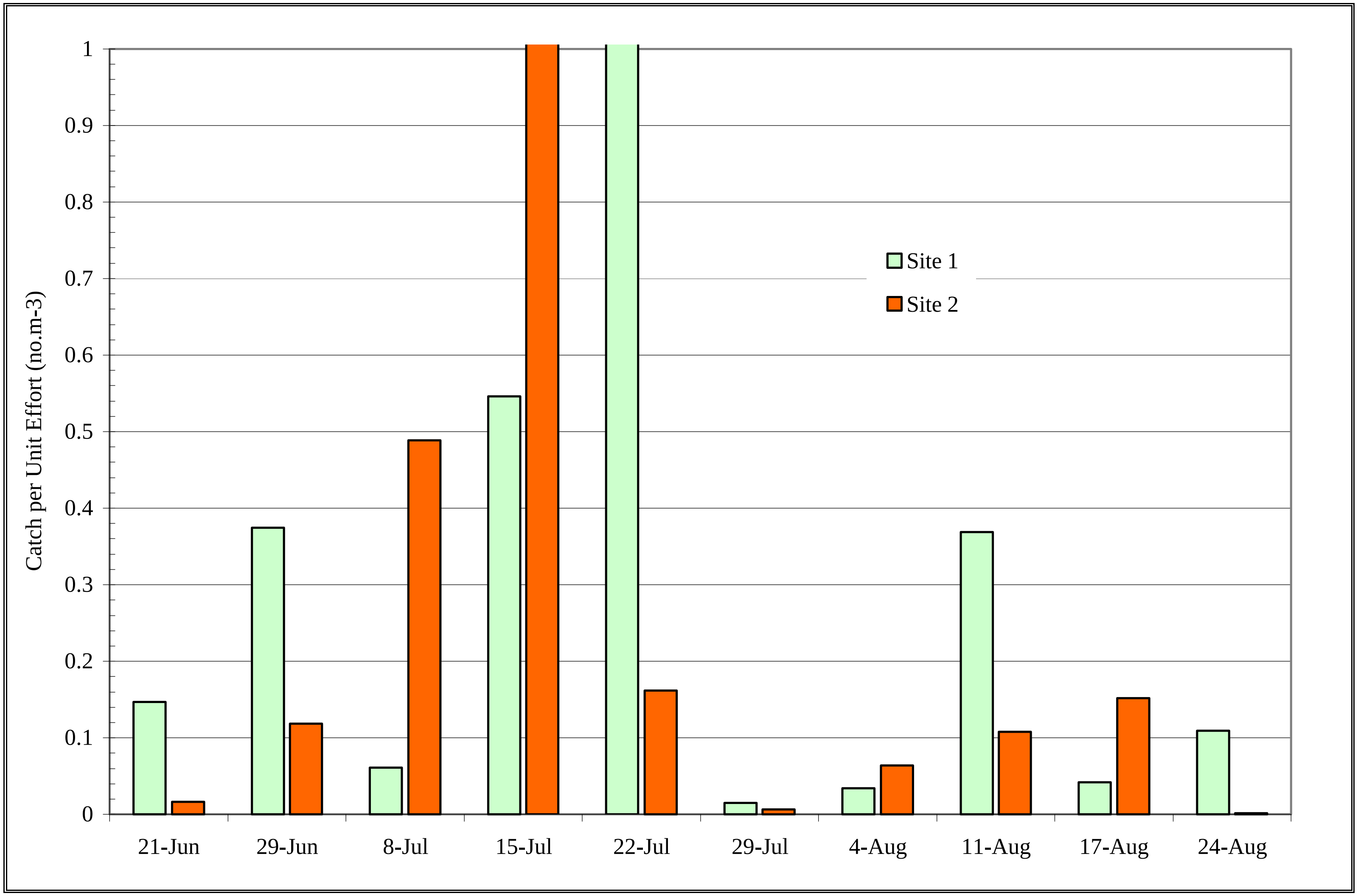

Figure 10. Catch per unit effort (no.· m^{-3}) indices of forage fish captured at each survey site during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

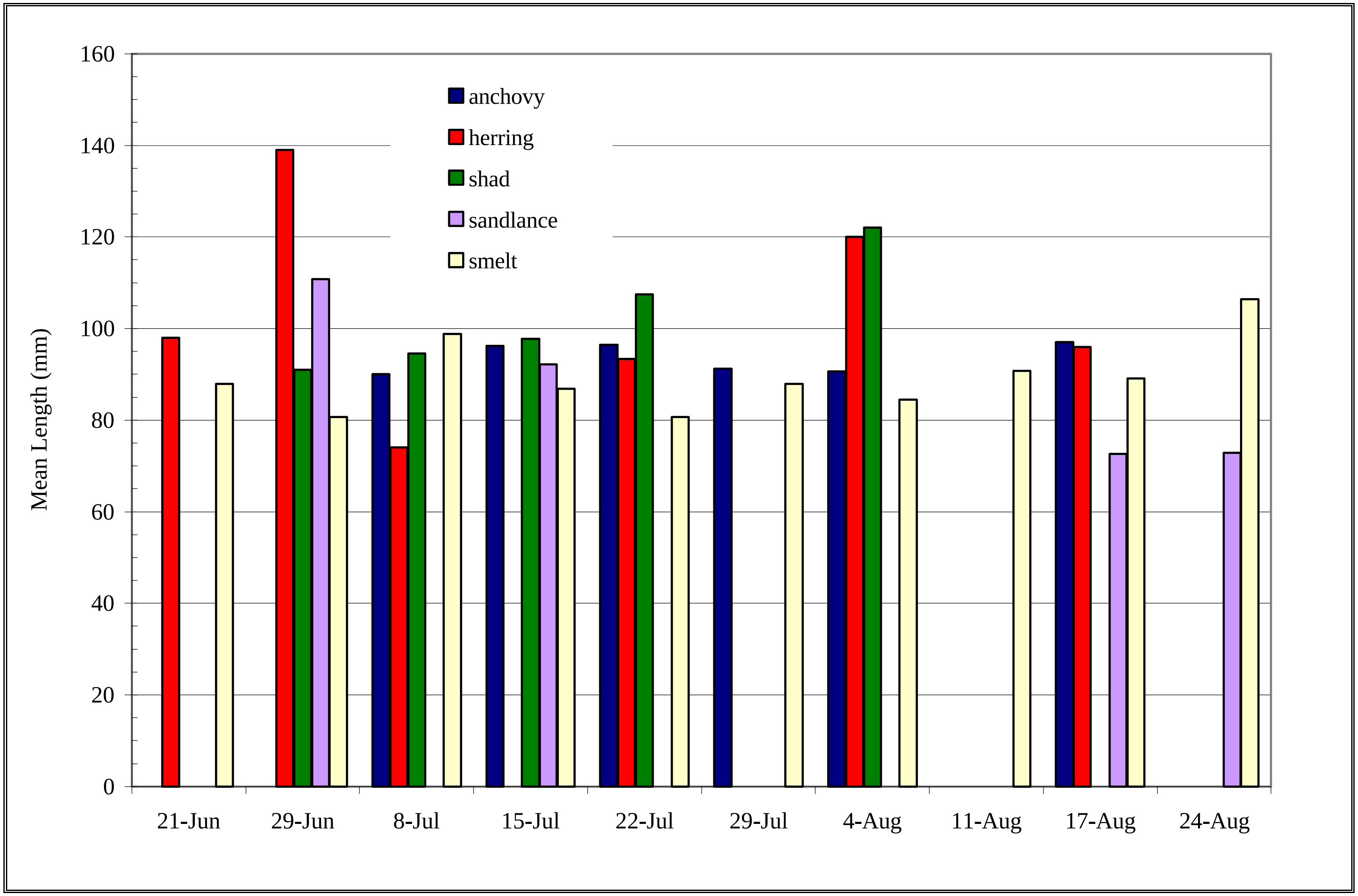

Figure 11. Mean length (mm TL) of forage fish captured at each survey site during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

4.4 OTHER SPECIES

Perch species, primarily shiner perch comprised the approximately 77% (CPUE=0.126) of the remaining species catch (Table 6). The other notable species include; rockfish (6%), sole (2%), and gunnel/prickleback (1%). The remaining species, except for crabs, each comprised less than 1% of the remaining species catch (0.1% of the overall total of fish and crabs) during surveys conducted in Half Moon Bay in 2004 (Table 6). Dungeness crab (primarily juvenile life stages), were the dominant crab species (>98%), comprised 13% of the remaining species catch, and approximately 1.5% of the overall species catch (Table 6).

Table 6. Species, total number, catch per unit effort (no. m^{-3}), percent composition of other fish, and percent composition of total fish and crabs captured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

Species	**Total Number**	**CPUE (no· m^{-3})**	**Percent Composition (other fish)**	**Percent Composition (total fish)**
Perch spp.	7,951	0.12581	76.56	8.725
Rockfish spp.	599	0.00948	5.77	0.657
Sole spp.	250	0.00396	2.41	0.274
Gunnel/Prickle spp.	115	0.00182	1.11	0.126
Greenling spp.	50	0.00079	0.48	0.055
T.S. Stickleback	43	0.00068	0.41	0.047
Flounder spp.	23	0.00036	0.22	0.025
B. Pipefish	4	0.00006	0.04	0.004
Cabezon	4	0.00006	0.04	0.004
Lingcod	2	0.00003	0.02	0.002
P Tomcod	1	0.00002	0.01	0.001
P. Sandfish	1	0.00002	0.01	0.001
D. Crab	1,321	0.02090	12.72	1.450
R.R. Crab	21	0.00033	0.20	0.023
Total	10,385	0.16432		11.39

4.5 WATER QUALITY

Tidal stage (as predicted at Westport, Point Chehalis) ranged from +8.5 to a (–1.0) mean lower low water on 4 August and 17 August, respectively (Table 7). Generally speaking, salinity values were higher on low tides and water temperatures were lower when compared to higher tidal values. Salinities ranged from 23.09 ppt on 24 August to a high of 31.38 ppt on 29 July, while water temperatures ranged from a high of 17.30ºC to a low of 12.20ºC on 11 August and 29 June, respectively (Table 7).

Table 7. Date, time, tide (predicted stage to nearest 0.1 ft in parenthesis), pH, salinity, water temperature, and dissolved oxygen (DO) concentration measured during beach seine surveys conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

Date	Time (hours)	Tide Stage	Water Temp (ºC)	Conductivity ($mS \cdot cm^{-1}$)	DO ($mg \cdot L^{-1}$)	pH	Salinity (ppt)
21 June	0930	Low (-1.0)	12.21	41.3	7.99	7.83	31.01
21 June	1530	High (7.0)	12.52	39.5	8.25	7.59	30.41
29 June	1130	High (6.5)	12.94	47.2	6.74	7.84	29.95
29 June	1630	Low (2.3)	12.20	45.3	8.13	7.56	30.12
8 July	1200	Low (0.3)	12.61	44.8	8.99	7.91	31.18
8 July	1900	High (8.2)	15.57	47.3	8.26	8.15	30.21
15 July	1300	High (6.7)	15.41	46.9	8.13	8.10	30.98
15 July	1800	Low (3.1)	12.98	45.1	8.87	7.89	31.15
22 July	1030	Low (-0.3)	16.61	45.4	9.03	8.07	29.05
22 July	1730	High (7.8)	16.97	46.0	6.70	8.02	29.30
29 July	1220	High (7.0)	14.89	47.4	7.59	8.08	30.33
29 July	1700	Low (2.6)	13.58	49.1	7.69	8.14	31.38
4 August	1000	Low (-0.9)	14.23	48.2	7.22	8.04	30.84
4 August	1700	High (8.5)	15.37	46.9	9.93	8.04	29.99
11 August	1100	High (6.1)	17.30	44.2	6.82	8.35	28.24
11 August	1630	Low (3.6)	15.58	46.0	8.79	8.34	29.43
17 August	0830	Low (-1.1)	14.07	39.7	8.20	7.93	24.88
17 August	1500	High (8.0)	15.61	39.1	8.86	8.05	24.53
24 August	0830	High (6.0)	15.95	37.0	8.23	8.30	23.09
24 August	1330	Low (3.2)	16.35	36.7	8.88	8.34	23.90

5. DISCUSSION/RECOMMENDATIONS

Estuarine and nearshore marine waters are considered important habitats for the early marine stages of Pacific salmon as well as spawning areas for adult forage fish. Estuaries provide salmonids with a transition zone for physical and behavioral adaptation to marine water. The extent of nearshore utilization can change between juvenile salmonid species, over the period of salmonid outmigration, or between spawning forage fish species. Subyearling Chinook salmon rear for extended periods, days or weeks, in nearshore waters before dispersing to epipelagic habitats (Healey 1991). Likewise, chum and pink salmon occupy the sublittoral zone for a period of time before moving offshore (Salo 1991; Heard 1991). Yearling Chinook salmon often migrate early in the spring and move directly into the neritic zone (Simenstad et al. 1982). Coho salmon smolts tend to follow similar patterns of yearling Chinook whereby they move quickly through estuarine habitats into the neritic zone (Sandercock 1991). Pacific sand lance select fine gravel and sandy beaches during the late fall and winter months to spawn. Spawning usually occurs in dense formations within presumably intertidal locations at preferred depths of less than 150 ft (Robards and Piatt 1999). Pacific sand lance are not known to utilize beaches exposed to heavy surf because of their tendency of lying buried in the sand for extended periods (Robards and Piatt 1999). Like their name implies, surf smelt regularly utilize beaches prone to surf as spawning habitats. Wave action buries fertilized surf smelt eggs to a depth of several millimeters in coarse sand (WDFW 2004).

This study indicated that from late June through August, juvenile Chinook salmon and juvenile/adult surf smelt were the most numerous and consistent inhabitant of Half Moon Bay. This period of Chinook residency coincides with past research efforts in upper Grays Harbor by Deschamps et al. (1970) and Brix (1981). Deschamps et al. (1970) found Chinook in beach seines in upper Grays Harbor from the end of April through the beginning of August, peaking in mid June. Brix (1981) also found that Chinook catches peaked in mid-June during beach seine surveys conducted from 1973 through 1980. Similar seine work conducted by R2 Resource Consultants in Half Moon Bay indicated that Chinook salmon had not yet moved into the study area by the final survey date of 21 May 1999; however, chum and coho salmon were found to be present during beach seine surveys (Jeanes and Hilgert 1999). Neither chum or coho salmon were captured during surveys conducted in 2004 (this study).

While direct comparisons to Jeanes and Hilgert (1999) are not valid because of different study periods and timing, the diversity of species and overall fish density was greater during the summer of 2004 when compared to spring surveys conducted in 1999. The two most numerous species captured in 2004, Northern anchovy and American shad, were not present in spring 1999 samples. Survey techniques, gear, and personnel were identical to 1999 surveys, so the resultant change is likely due to the survey period (i.e., spring vs summer). Overall, mean catch per unit effort indices much higher in 2004 (CPUE = 1.44 individuals$\cdot$ m^{-3}) compared to surveys conducted in 1999 (CPUE = 0.13 individuals$\cdot$ m^{-3}). However, species composition of the overall catch was similar in that surf smelt were the most numerous and consistent species captured in 1999 and along with Chinook salmon, were the only species captured at each survey event in 2004.

Only recently has information been available on the habits of marine-resident native char in Washington waters (Goetz et al. 2004). Saltwater migratory bull trout are considered a unique ecological trait for bull trout in the contiguous U.S., although the majority of information was derived from recent studies of saltwater migratory individuals in estuary and nearshore marine areas of Puget Sound. The typical pattern is for juvenile fish to migrate from freshwater natal areas between late winter to spring to feed in marine environments (estuarine or nearshore) during late spring and early summer. Native char then enter fresh water in late spring through summer to overwinter, feed, seek refuge, or spawn, typically returning to sea water the next spring. This life history may not be fully manifested in juvenile bull trout, but may be displayed more in older fish, sub-adults and adults. Further, this life history may be alternated year to year by individual fish, whereby in one year they are anadromous in the next they become a freshwater migrant. Native char were not present in Half Moon Bay during the summer of 2004. The information collected from biotelemetry studies of native char in the lower Chehalis River indicate that sub-adult char leave foraging areas in the lower river by mid-July, presumably relating to extended periods of elevated (17ºC) water temperatures. Native char were not present at a fixed receiver station located between Half Moon Bay and the Westport Boat Basin. Native char have returned to the lower Chehalis River in consecutive years indicating site fidelity to Grays Harbor, and the importance of this region to coastal bull trout populations, however it appears they do not utilize Half Moon Bay during their seaward migration from the lower Chehalis River.

Half Moon Bay represents a unique feature to fish and crab species inhabiting Grays Harbor whereby a diversity of both sheltered and non-sheltered nearshore tidal habitats are in close proximity to the Pacific Ocean. This study indicated that fish and crab assemblages are both diverse and numerous throughout the summer period. We did not find significant differences between catch indices between survey sites or within tidal cycles due to the variation in catch. Juvenile Chinook and surf smelt were a consistent inhabitant of Half Moon Bay throughout the study period. Beach seine survey should be conducted in Half Moon Bay during months that have not been surveyed to date. A year-round sampling strategy would be wise given the known variation in catch. Beach seine surveys conducted in the winter months will indicate if Pacific sand lance utilize Half Moon Bay as spawning habitat. The continuation of fixed receivers in Grays Harbor will continue to provide valuable information on the migration habits of anadromous native char on the Washington coastline. The information will prove valuable in defining duration of use of Half Moon Bay by fish and crab species with respect to potential impacts resulting from continued maintenance and periodic construction activities proposed for the Grays Harbor Federal Navigation Channel.

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APPENDIX A

Photograph Log

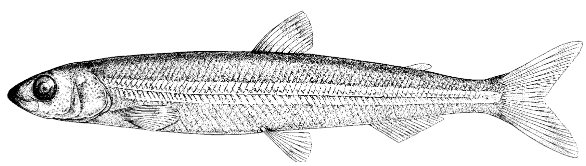

Figure A-1. Beach seine survey Site 1 at approximately +5.0 ft MLLW tide elevation, Half Moon Bay, Westport, Washington, 2004.

Figure A-2. Beach seine survey Site 2 at approximately +0.5 ft MLLW tide elevation, Half Moon Bay, Westport, Washington, 2004.

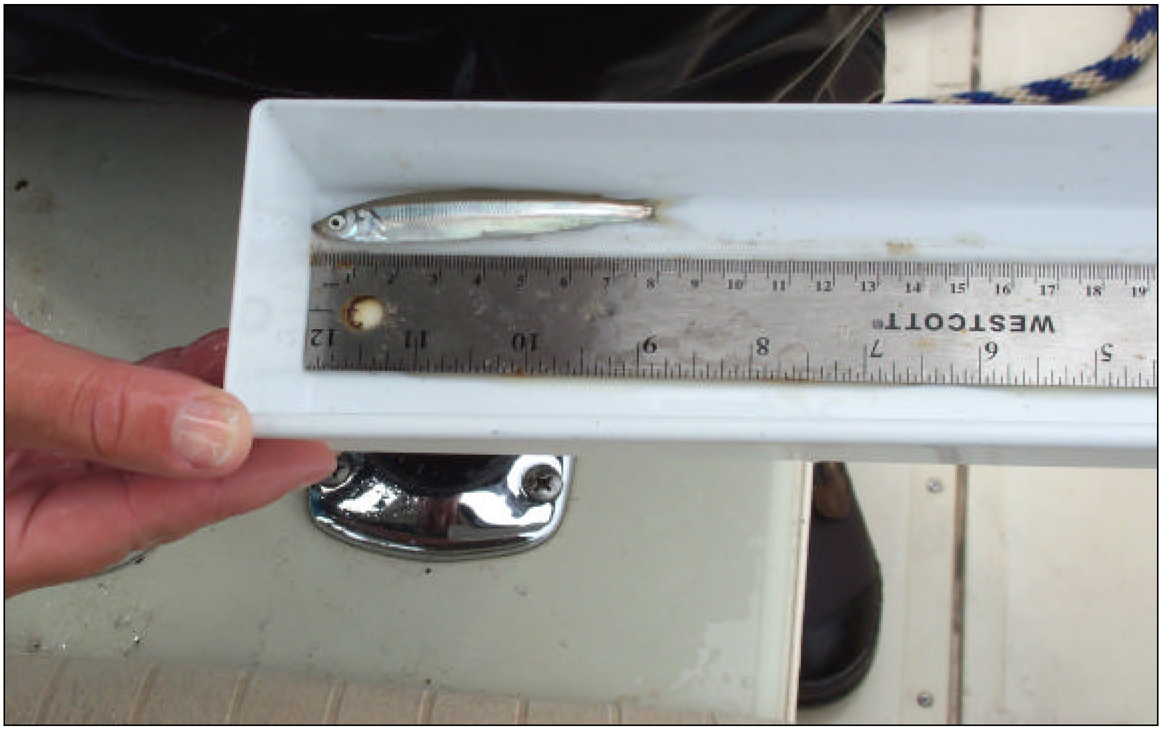

Figure A-3. Surf smelt captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-4. Buffalo sculpin captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-5. Juvenile cabezon captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-6. Juvenile rockfish captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-7. Juvenile greenling captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-8. Pacific sandfish captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-9. Starry flounder captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

Figure A-10. Silver surfperch captured during beach seine surveys conducted in Half Moon Bay, Westport, Washington, 2004.

APPENDIX B

Beach Seine Data

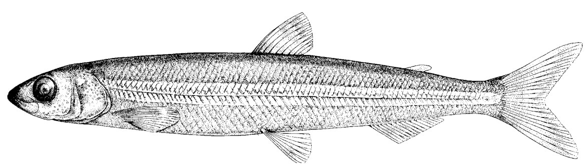

Table B-1. Number of fish and crabs captured during individual beach seine hauls conducted in Half Moon Bay, Grays Harbor, Washington, 2004.

Date	Site	Tide	N. Anchovy	Cabezon	Chinook	Cutthroat	D. Crab	R.R. Crab	Greenling	Gunnel/ Prickle	P. Herring	Lingcod	Perch spp.	B. Pipefish	Rainbow	Rockfish spp.	P. sandfish	P.S. Lance	A. Shad	Smelt spp.	Sole spp.	Flounder spp.	Sculpin spp.	Stickleback	P. Tomcod	Total
21-Jun-04	Site 1	low			14		142	1	7	1			7							361	44	5	40			622
21-Jun-04	Site 1	low			1		62		2	1			7			1				14	57	1	14	2		162
21-Jun-04	Site 1	high			14						1		27			20				50						112
21-Jun-04	Site 1	high			20		7		1				36			3				38			2			107
21-Jun-04	Site 2	low			21		5	2	1				87							19	7		1			143
21-Jun-04	Site 2	low			28		2						23							22	6	1		2		84
21-Jun-04	Site 2	high			11								195							4			4			214
21-Jun-04	Site 2	high			13		3						117							7			7			147
29-Jun-04	Site 1	high			26		47		1	1	1		224					4		25	4	2	26	1	1	363
29-Jun-04	Site 1	high			76		14	1					249					4		12	1	1	3			361
29-Jun-04	Site 1	low			98		113				1		85			3			3	166	5	1	17	2		494
29-Jun-04	Site 1	low	4		270		34			1	2		82		1	9		9	1	951	3		4	3		1374
29-Jun-04	Site 2	high			45								85							2		1				133
29-Jun-04	Site 2	high			35						1		116							1				1		154
29-Jun-04	Site 2	low											540			3				342		1	1			887
29-Jun-04	Site 2	low			3		3						67							29						102
8-Jul-04	Site 1	low	7		37		242			4			74						1	39	14	2	84			504
8-Jul-04	Site 1	low	9		46	1	274			5			90							119	20		43			607
8-Jul-04	Site 1	high			10			1					178							9			3			201
8-Jul-04	Site 1	high			9		2	1			1		183							9			1			206
8-Jul-04	Site 2	low	373		6								157						61	495						1092
8-Jul-04	Site 2	low	107		4								21						3	493			2			630
8-Jul-04	Site 2	high			7								75							8				1		91
8-Jul-04	Site 2	high			6					1			52							4			2			65
15-Jul-04	Site 1	high			8		5			1			351							242			2			609
15-Jul-04	Site 1	high			17		2						308	1						155	1		2			486
15-Jul-04	Site 1	low	1		54		4						166					12		753			8			998
15-Jul-04	Site 1	low			28		9						44							562			3			646
15-Jul-04	Site 2	high	1		12		1						100							24			2			140
15-Jul-04	Site 2	high			7								147					2		8			2			166

Date	Site	Tide	N. Anchovy	Cabezon	Chinook	Cutthroat	D. Crab	R.R. Crab	Greenling	Gunnel/ Prickle	P. Herring	Lingcod	Perch spp.	B. Pipefish	Rainbow	Rockfish spp.	P. sandfish	P.S. Lance	A. Shad	Smelt spp.	Sole spp.	Flounder spp.	Sculpin spp.	Stickleback	P. Tomcod	Total
15-Jul-04	Site 2	low	24000		300														13700	4700						42700
15-Jul-04	Site 2	low	200		100								117					67	3383	83						3950
22-Jul-04	Site 1	low			2		33	2		44			182			31				115	14		29			452
22-Jul-04	Site 1	low			10		25	7	2	51			202			39				421	26		4			787
22-Jul-04	Site 1	high	11700				75				225		75						10800							22875
22-Jul-04	Site 1	high	35		116								103						46	68			3			371
22-Jul-04	Site 2	low			12		1						274							73	3		1			364
22-Jul-04	Site 2	low			4		10						170							51	5		6			246
22-Jul-04	Site 2	high			76								234					4		292				2		608
22-Jul-04	Site 2	high			62								137					1		90			1	5		296
29-Jul-04	Site 1	high			2		31						318				1			3	1		7			363
29-Jul-04	Site 1	high			4		13						158							1	1	1	3	1		182
29-Jul-04	Site 1	low	5		25		11						57							21			11			130
29-Jul-04	Site 1	low			18		27			1			34							18			9			107
29-Jul-04	Site 2	high			6								38							1	1			1		47
29-Jul-04	Site 2	high			8								100							4			1	1		114
29-Jul-04	Site 2	low	1		5		5						34										3			48
29-Jul-04	Site 2	low			12								42							15			2			71
4-Aug-04	Site 1	low	4				12		9	2			176			11			1	54	7	1	22			299
4-Aug-04	Site 1	low	1		1		10		10				207			23			7	28	2	2	7	2		300
4-Aug-04	Site 1	high											10							1	1		1			13
4-Aug-04	Site 1	high											8							11		1				20
4-Aug-04	Site 2	low			10								46							72	4	1	1			134
4-Aug-04	Site 2	low			3		3				1		71							129	1		3			211
4-Aug-04	Site 2	high			1								260							1			1			263
4-Aug-04	Site 2	high					1						77									1	1	3		83
11-Aug-04	Site 1	high			4								44							607						655
11-Aug-04	Site 1	high	1		2								19							178			1			201
11-Aug-04	Site 1	high			3				1				58			16				199	1		11			289
11-Aug-04	Site 1	high			6								23			2				181			1			213
11-Aug-04	Site 2	high			1								15							243	1		3			263
11-Aug-04	Site 2	high			5								27							12				2		46
11-Aug-04	Site 2	high			2								187							40			4	1		234

Date	Site	Tide	N. Anchovy	Cabezon	Chinook	Cutthroat	D. Crab	R.R. Crab	Greenling	Gunnel/ Prickle	P. Herring	Lingcod	Perch spp.	B. Pipefish	Rainbow	Rockfish spp.	P. sandfish	P.S. Lance	A. Shad	Smelt spp.	Sole spp.	Flounder spp.	Sculpin spp.	Stickleback	P. Tomcod	Total
11-Aug-04	Site 2	high			3								75	1						45			3			127
17-Aug-04	Site 2	low	5		4		3						33					1		357	6		9	2		420
17-Aug-04	Site 2	low			1		1				1		7					64		43	6		14	1		138
17-Aug-04	Site 2	high			3								14			1				7		1		3		29
17-Aug-04	Site 2	high			6								28							3			2	3		42
17-Aug-04	Site 1	low		2	4		49	3	9	1		1	31			336				96	3		16	1		552
17-Aug-04	Site 1	low		2			40	3	4				85			90				7	4		18			253
17-Aug-04	Site 1	high											9							22			3	1		35
17-Aug-04	Site 1	high											17							8			4	1		30
24-Aug-04	Site 2	low			2								58	1						5			3			69
24-Aug-04	Site 2	low			1								17													18
24-Aug-04	Site 2	low											1							1						2
24-Aug-04	Site 2	low			2								7													9
24-Aug-04	Site 1	low											10							17						27
24-Aug-04	Site 1	low											14							12			1	1		28
24-Aug-04	Site 1	low							3	1		1	94	1		6					1		33			140
24-Aug-04	Site 1	low											55			5		316					2			378
TOTALS			36454	4	1752	1	1321	21	50	115	234	2	7951	4	1	599	1	484	28006	13298	250	23	517	43	1	91132